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NEW JERSEY DEPT OF ENVIRONMENTAL PROTECTION TRENTON F/6 13/13  
NATIONAL DAM SAFETY PROGRAM, DEER HEAD LAKE DAM (NJ00789), ATLA--ETC(U)  
MAY 81 J P TALERICO DACW61-79-C-0011

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ATLANTIC COASTAL BASIN,  
NORTH BRANCH OF FORKED RIVER,  
OCEAN COUNTY,  
NEW JERSEY.

LEVEL II

DEER HEAD LAKE DAM

(NJ 00789)

DTIC  
ELECT

JUN 19 1981

PHASE I INSPECTION REPORT.  
NATIONAL DAM SAFETY PROGRAM

(1) Final Report

(10) John P. Talarico

(11) May 1981

(12) 84

(13) DAEN-11-C-411



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Philadelphia District  
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Philadelphia, Pennsylvania

REPT. NO. DAEN NAP 53842 NJ 00789 - 81/05

MAY 1981

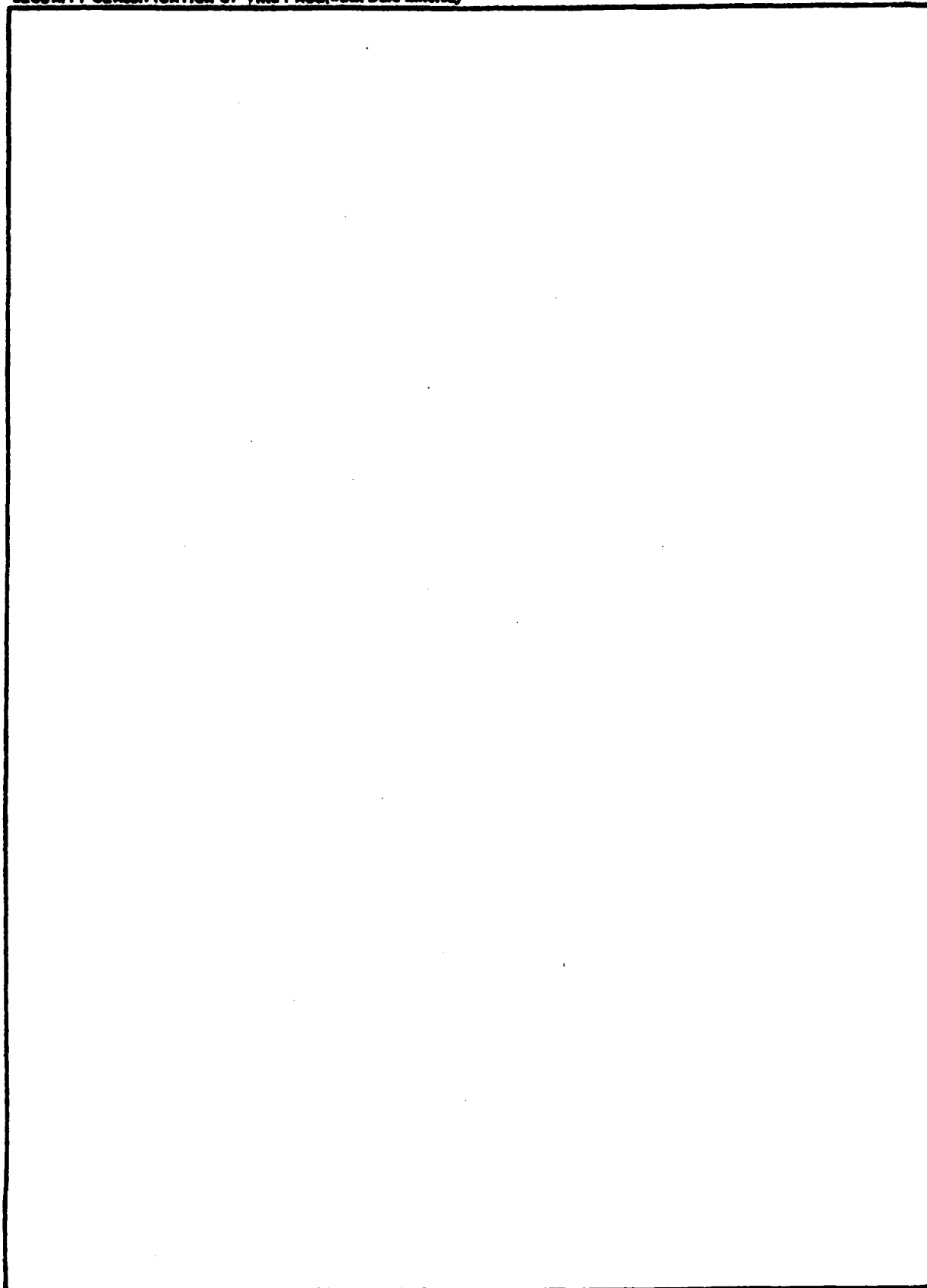
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| 4. TITLE (and Subtitle)<br>Phase I Inspection Report<br>National Dam Safety Program<br>Deer Head Lake Dam, NJ00789<br>Ocean County, NJ   |                                     | 5. TYPE OF REPORT & PERIOD COVERED<br>FINAL                    |
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| 19. KEY WORDS (Continue on reverse side if necessary and identify by block number)<br>Dams                                      National Dam Safety Program                      Outlet Works<br>Embankments                              Deer Head Lake Dam, NJ<br>Visual Inspection                              Spillways<br>Structural Analysis                              Embankments   |                                     |  |
| 20. ABSTRACT (Continue on reverse side if necessary and identify by block number)<br>This report cites results of a technical investigation as to the dam's adequacy. The inspection and evaluation of the dam is as prescribed by the National Dam Inspection Act, Public Law 92-367. The technical investigation includes visual inspection, review of available design and construction records, and preliminary structural and hydraulic and hydrologic calculations, as applicable. An assessment of the dam's general condition is included in the report. |                                     |  |

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5 JUN 1981

Honorable Brendan T. Byrne  
Governor of New Jersey  
Trenton, New Jersey 08621

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DISTRIBUTION UNLIMITED.

Dear Governor Byrne:

Inclosed is the Phase I Inspection Report for Deer Head Lake Dam in Ocean County, New Jersey which has been prepared under authorization of the Dam Inspection Act, Public Law 92-367. A brief assessment of the dam's condition is given in the front of the report.

Based on visual inspection, available records, calculations and past operational performance, Deer Head Lake Dam, a high hazard potential structure, is judged to be in good overall condition. The dam's spillways are considered inadequate because a flow equivalent to eight percent of the Spillway Design Flood - SDF - would cause the dam to be overtopped. (The SDF, in this instance, is one half of the Probable Maximum Flood). The decision to consider the spillways "inadequate" instead of "seriously inadequate" is based on the determination that dam failure resulting from overtopping would not significantly increase the hazard to loss of life downstream from the dam from that which would exist just before overtopping failure. To ensure adequacy of the structure, the following actions, as a minimum, are recommended:

a. The spillways' adequacy should be determined by a qualified professional consultant engaged by the owner using more sophisticated methods, procedures and studies within six months from the date of approval of this report. Within three months of the consultant's findings remedial measures to ensure spillway adequacy should be initiated. In the interim, a detailed emergency operation plan and warning system should be promptly developed. Also, during periods of unusually heavy precipitation, around the clock surveillance should be provided.

b. Within twelve months from the date of approval of this report, the following remedial actions should be completed:

- (1) Repair the stilling basin of the left spillway with epoxy cement.

NAPEN-N

Honorable Brendan F. Byrne

(2) Repair concrete surfaces of the left spillway with epoxy cement.

(3) Fill in the eroded section of channel at the discharge apron of the left spillway with appropriate material and then riprap the channel bottom to prevent future erosion.

(4) Clean out sediment from the outlet end of the discharge pipe and immediately downstream of the outlet.

(5) Fill in eroded areas of the embankment with appropriate material.

c. The owner should develop written operating procedures and a periodic maintenance plan to ensure the safety of the dam within one year from the date of approval of this report.

A copy of the report is being furnished to Mr. Dirk C. Holman, New Jersey Department of Environmental Protection, the designated State Office contact for this program. Within five days of the date of this letter, a copy will also be sent to Congressman Hughes of the Second District. Under the provision of the Freedom of Information Act, the inspection report will be subject to release by this office, upon request, five days after the date of this letter.

Additional copies of this report may be obtained from the National Technical Information Services (NTIS), Springfield, Virginia 22161 at a reasonable cost. Please allow four to six weeks from the date of this letter for NTIS to have copies of the report available.

An important aspect of the Dam Inspection Program will be the implementation of the recommendations made as a result of the inspection. We accordingly request that we be advised of proposed actions taken by the State to implement our recommendations.

Sincerely,



KENNETH R. MOSER  
Major, Corps of Engineers  
Acting District Engineer

1 Incl  
As stated

Copies furnished:

Mr. Dirk C. Holman, P.E., Deputy Director  
Division of Water Resources  
N.J. Dept. of Environmental Protection  
P.O. Box CN029  
Trenton, NJ 08625

Mr. John O'Dowd, Acting Chief  
Bureau of Flood Plain Regulation  
Division of Water Resources  
N.J. Dept. of Environmental Protection  
P.O. Box CN029  
Trenton, NJ 08625



DEER HEAD LAKE DAM (NJ60739)

CORPS OF ENGINEERS ASSESSMENT OF GENERAL CONDITIONS

This dam was inspected on 14 January and 15 February 1981 by Harris-ECI Associates, under contract to the State of New Jersey. The State, under agreement with the U.S. Army Engineer District, Philadelphia, had this inspection performed in accordance with the National Dam Inspection Act, Public Law 92-367.

Deer Head Lake Dam, a high hazard potential structure, is judged to be in good overall condition. The dam's spillways are considered inadequate because a flow equivalent to eight percent of the Spillway Design Flood - SDF - would cause the dam to be overtopped. (The SDF, in this instance, is one half of the Probable Maximum Flood). The decision to consider the spillways "inadequate" instead of "seriously inadequate" is based on the determination that dam failure resulting from overtopping would not significantly increase the hazard to loss of life downstream from the dam from that which would exist just before overtopping failure. To ensure adequacy of the structure, the following actions, as a minimum, are recommended:

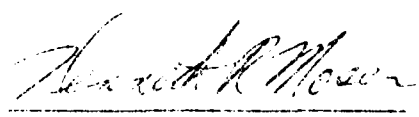
a. The spillways' adequacy should be determined by a qualified professional consultant engaged by the owner using more sophisticated methods, procedures and studies within six months from the date of approval of this report. Within three months of the consultant's findings remedial measures to ensure spillway adequacy should be initiated. In the interim, a detailed emergency operation plan and warning system should be promptly developed. Also, during periods of unusually heavy precipitation, around the clock surveillance should be provided.

b. Within twelve months from the date of approval of this report, the following remedial actions should be completed:

- (1) Repair the stilling basin of the left spillway with epoxy cement.
- (2) Repair concrete surfaces of the left spillway with epoxy cement.
- (3) Fill in the eroded section of channel at the discharge apron of the left spillway with appropriate material and then riprap the channel bottom to prevent future erosion.
- (4) Clean out sediment from the outlet end of the discharge pipe and immediately downstream of the outlet.
- (5) Fill in eroded areas of the embankment with appropriate material.

c. The owner should develop written operating procedures and a periodic maintenance plan to ensure the safety of the dam within one year from the date of approval of this report.

APPROVED:

  
KENNETH R. MOSER  
Major, Corps of Engineers  
Acting District Engineer

DATE:

4 June 1981

ATLANTIC COASTAL BASIN  
NORTH BRANCH OF FORKED RIVER, OCEAN COUNTY  
NEW JERSEY

DEER HEAD LAKE DAM

NJ00789

PHASE I INSPECTION REPORT  
NATIONAL DAM SAFETY PROGRAM

DEPARTMENT OF THE ARMY  
PHILADELPHIA DISTRICT, CORPS OF ENGINEERS  
PHILADELPHIA, PENNSYLVANIA 19106

MAY, 1981

PHASE I INSPECTION REPORT  
NATIONAL DAM SAFETY PROGRAM

Name : Deer Head Lake Dam, I.D. NJ 00789  
State Located : New Jersey  
County Located : Ocean County  
Stream : North Branch Forked River  
River Basin : Atlantic Coastal Basin  
Date of Inspection : January 14, and February 15, 1981

Assessment of General Conditions

Deer Head Lake Dam is an earthfill dam with a paved roadway across the crest. The original embankment has been filled in on both sides to form a swimming beach and a parking area. There are two spillways; a concrete weir at the left end of the dam and a timber drop inlet at the right. The overall condition of the dam is good. There are no signs of distress or instability in the embankment. There are two separate downstream channels that are in good condition. The hazard potential is rated as "high".

Deer Head Lake Dam is considered inadequate in view of its lack of spillway capacity to pass the SDF (1/2 PMF) without overtopping the dam. The spillway is capable of passing a flood equal to 3.7 percent of the PMF (7.4 percent of the 1/2 PMF), and is assessed as "inadequate".


At present, the engineering data available is not sufficient to make a definitive statement on the stability of the dam, but based on the findings of the visual inspection, the preliminary assessment of static stability is that it is satisfactory. The following actions are recommended along with a timetable for their completion. All recommended actions should be conducted under the supervision of an Engineer who is experienced in the design, construction and inspection of dams.

1. Carry out a more precise hydrologic and hydraulic analysis of the dam within twelve months, to determine the need and type of mitigating measures necessary. Based on the results of these studies, remedial measures should be instituted. This should include the installation of a tailwater gage.
2. Repair stilling basin of left spillway with epoxy cement within twelve months.
3. Repair concrete surfaces of left spillway with epoxy cement within twelve months.

4. Fill in eroded section of channel at discharge apron with appropriate material and riprap channel bottom to prevent future erosion. This work should be completed within twelve months.
5. Clean out sediment from the outlet end of the discharge pipe and immediately downstream of outlet within twelve months.
6. Fill in eroded areas of embankment with appropriate material. This should be done within twelve months.
7. The owner should develop an emergency action plan (if one is not already available) outlining actions to be taken by the operator to minimize downstream effects of an emergency and establish a flood warning system for the downstream communities within three months.

Furthermore, while of a less urgent nature, the following additional actions are recommended and should be carried out within twelve months.

1. The owner should develop, within one (1) year after formal approval of the report, written operating procedures and a periodic maintenance plan to insure the safety of the dam.
2. Conduct a complete topographic survey of the dam and surrounding area, in order to develop a detailed plan and several cross-sections of the dam. Annotate and update the existing drawings, and form a coherent as-built set.



John P. Talerico, P.E.  
HARRIS-ECI ASSOCIATES

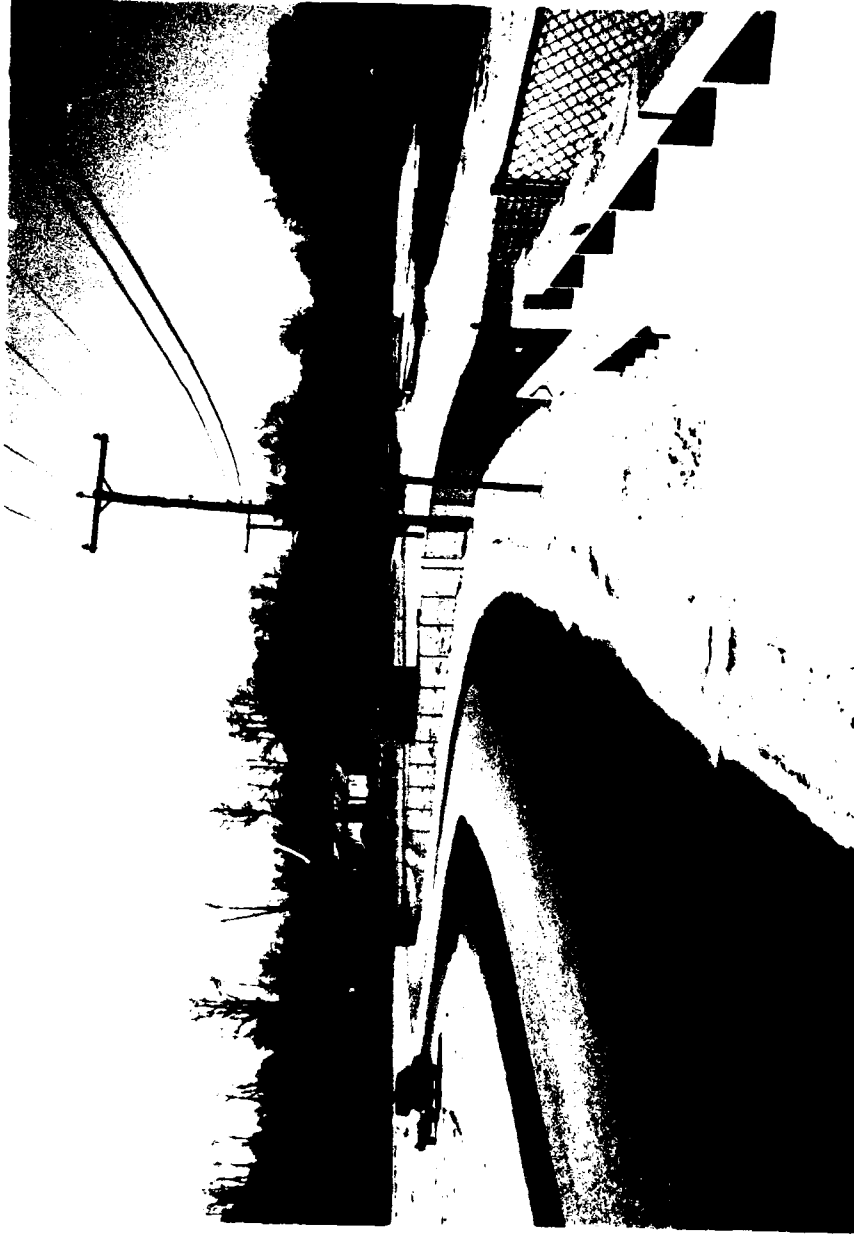


Photo taken on February 15, 1981

# DEER HEAD LAKE DAM

View looking towards right end of dam. Concrete weir spillway is just out of view in the lower right of the photo.

## PREFACE

This report is prepared under guidance contained in the Recommended Guidelines for Safety Inspection of Dams, for Phase I Investigations. Copies of these guidelines may be obtained from the office of the Chief of Engineers, Washington, D.C. 20314. The purpose of a Phase I Investigation is to identify expeditiously those dams which may pose hazards to human life or property. The assessment of the general condition of the dam is based upon available data and visual inspections. Detailed investigation, and analyses involving topographic mapping, subsurface investigations, testing, and detailed computational evaluations are beyond the scope of a Phase I investigation; however, the investigation intended to identify any need for such studies.

In reviewing this report, it should be realized that the reported condition of the dam is based on observations of field conditions at the time of inspection along with data available to the inspection team. It is important to note that the condition of a dam depends on numerous and constantly changing internal and external conditions, and is evolutionary in nature. It would be incorrect to assume that the present condition of the dam will continue to represent the condition of the dam at some point in the future. Only through continued care and inspection can there be any chance that unsafe conditions be detected.

Phase I inspections are not intended to provide detailed hydrologic and hydraulic analyses. In accordance with the established Guidelines, the Spillway Test flood is based on the estimated "Probable Maximum Flood" for the region (greatest reasonably possible storm runoff), or fractions thereof. The test flood provides a measure of relative spillway capacity and serves as an aide in determining the need for more detailed hydrologic and hydraulic studies, considering the size of the dam, its general condition and the downstream damage potential.

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PHASE I INSPECTION REPORT  
NATIONAL DAM SAFETY PROGRAM

DEER HEAD LAKE DAM, I.D. NJ 00789

S E C T I O N 1

1. PROJECT INFORMATION

1.1 General

a. Authority

The National Dam Inspection Act (Public Law 92-367, 1972) provides for the National Inventory and Inspection Program by the U.S. Army Corps of Engineers. This inspection was made in accordance with this authority under Contract C-FPM No. 35 with the State of New Jersey who, in turn, is contracted to the Philadelphia District of the Corps of Engineers, and was carried out by the engineering firm of Harris-ECI Associates of Woodbridge, New Jersey.

b. Purpose of Inspection

The visual inspection of Deer Head Lake Dam was made on January 14 and February 15, 1981. The purpose of the inspection was to make a general assessment as to the structural integrity and operational adequacy of the dam embankment and its appurtenant structures.

c. Scope of Report

The report summarizes available pertinent data relating to the project; presents a summary of visual observations made during the field inspection; presents an evaluation of hydrologic and hydraulic conditions at the site; presents an evaluation as to the structural adequacy of the various project features; and assesses the general condition of the dam with respect to safety.

1.2 Description of Project

a. Description of Dam and Appurtenances

Deer Head Lake Dam was originally constructed as a 500 foot long earthfill dam with a road across the crest. At the left end of the dam was a timber bridge over the spillway. Since then, the downstream area has been filled in to provide a parking area for the beach along the upstream slope and a new concrete bridge built 32 feet downstream of the old bridge. There are

two spillways, 39 foot wide broad crested concrete weir at the left end of the dam and a 13-foot x 13-foot timber drop inlet at the right end. The distance between spillways is approximately 660 feet. The crest of the concrete weir spillway is 3.4 feet below the top of the old bridge and 5.1 feet below the new bridge.

The crest of the drop inlet spillway is 3-inches above the left spillway and 1.8 feet below the top of roadway at the inlet. There is a one-inch steel bar screen cover across the top of the inlet. The flow from the concrete weir discharges onto a concrete apron under the old bridge. The flow from the drop inlet discharges into the right downstream channel through a 72-inch corrugated metal pipe, which has anti-seep collars extending three feet beyond the outside of the pipe.

In addition to the downstream side of the original dam being filled in, the upstream area has been filled in with sand to create a bench along the entire length of the dam. At the widest point the width of the crest is approximately 390 feet including a 125 foot beach area. The height of the dam being 9.4 feet.

The low-level outlet consists of two sets of three foot long timber stop planks attached to the upstream face of the timber drop inlet. The planks are removed and replaced manually.

The downstream channel for the left spillway begins at the end of the concrete apron approximately 23 feet from the spillway and flows under the new bridge, 32 feet away, through a 34 foot x 9 foot opening. The outlet end of the right spillway discharges into the right downstream channel approximately 200 feet from the inlet. Both channels flow into a marsh area and then eventually into Lake Barnegat approximately 1,400 feet downstream.

A generalized description of the soil conditions is contained in Report No. 8, Ocean County, Engineering Soil Survey of New Jersey by Rutgers University. The report dated 1953 indicates the area of the dam and lake to be a complex intermingling of alluvium, with man-made features, marine tidal marsh and swamp. Geologic Overlay Sheet 33 classifies the underlaying material as beach sand.

b. Location

Deer Head Lake Dam is located on the North Branch of the Forked River, in the Township of Lacey, Ocean County, New Jersey. The dam is accessible from U.S. Route 9 in Forked River by way of Lakeside Drive South to Deerhead Lake Drive.

c. Size Classification

According to the "Recommended Guidelines for Safety Inspection of Dams" by the U.S. Department of the Army, Office of the Chief Engineers, the dam is classified in the dam size category as being "small", since its storage volume of 132 acre-feet is less than 1,000 acre-feet. The dam is also classified as "small" because its height of 9.4 feet is less than 40 feet. The overall size classification of Deer Head Lake Dam is "small".

d. Hazard Classification

A hazard potential classification of "high" has been assigned to the dam on the basis that a hypothetical failure could result in extensive damage to the homes along Lake Barnegat immediately downstream and also the possible failure of the downstream dam itself. Therefore the possibility exists of the loss of more than a few lives in the event of dam failure.

e. Ownership

Deer Head Lake Dam is owned by:

Lacey Township  
Public Works Department  
818 W. Lacey Road  
Forked River, NJ 08731

Attention: Mr. Robert Albert  
Superintendent Public Works  
(609)693-2402

f. Purpose

Deer Head Lake Dam is presently used for recreation purposes only.

g. Design and Construction History

The original construction date for Deer Head Lake Dam is unknown. The dam was built to provide water for a mill located at the right edge of the dam. At that time there were two spillways, a timber spillway at the left end and a timber flume at the right. In 1930 the mill and flume burned. The flume was filled in and two new timber spillways were built, one at the right end and the other in the middle of the dam.

In 1952, the left spillway was replaced with a wider spillway with the flow being controlled by stop planks. This spillway was inturn replaced with the present concrete weir in 1968. The other two spillways were replaced by the present drop inlet at the right end of the dam in 1974. At that time a second drop inlet spillway was to be constructed the following year, but was never built. The original plans for the drop inlets called for the two discharge pipes to be 48-inch corrugated metal pipes. Upon reviewing the plans, the Bureau of Water Control advised that pipe sizes should be larger, but due to the urgency of replacing the existing spillways, the work was started before the revised plans were done.

h. Normal Operating Procedures

The discharge from the lake is unregulated and allowed to balance the inflow into the lake. The low-level outlets are used to lower the lake level occasionally for repairs and to clean the swimming area.

### 1.3 Pertinent Data

a. Drainage Area 13.8 sq. mi.

b. Discharge at Dam Site

Ungated spillway capacity at elevation of top of dam: 681 (24.5 NGVD)

Total spillway capacity at maximum pool elevation (SDF): 9,037 (27.1 NGVD)

c. Elevation (Feet above NGVD)

Top of dam: 24.5

Maximum pool design surcharge (SDF): 27.1

Recreation pool: 22.5

Spillway crest: Left: 22.5  
Right: 22.75

Streambed at centerline of dam: Left: 16 (Estimated)  
Right: 14 (Estimated)

Maximum tailwater: Left: 17.5 (Estimated)  
Right: 15.0 (Estimated)

d. Reservoir

Length of maximum pool: 4,000 ft. (Estimated)

Length of recreation pool: 3,200 ft. (Estimated)

e. Storage (acre-feet)

Spillway Crest: 48.0 (22.5 NGVD)

Top of dam: 132.0

Maximum pool (SDF): 309

f. Reservoir Surface (acres)

Top of dam: 65

Maximum pool (SDF): 90

Recreation pool: 32

Spillway crest: 32 (22.5 NGVD)

g. Dam

|                         |   |
|-------------------------|---|
| Type:                   | Earthfill with broad crested concrete weir and timber drop inlet spillways. |
| Length:                 | 660 ft. (Effective)   |
| Height:                 | 9.4 ft.   |
| Top width:              | Varies-390 ft. maximum  |
| Side slopes - Upstream: | 10H:1V and flatter  |
| - Downstream:           | 2H:1V   |
| Zoning:                 | Unknown   |
| Impervious core:        | None  |
| Cutoff:                 | None  |
| Grout curtain:          | None  |

h. Diversion and Regulating Tunnel

i. Spillway

|                  |                                   |
|------------------|-----------------------------------|
| Type:            | Left: Broad crested concrete weir |
|                  | Right: Timber drop inlet          |
| Length of weir:  | Left: 39 ft.                      |
|                  | Right: 41.5 ft.                   |
| Crest elevation: | Left: 22.5 NGVD                   |
|                  | Right: 22.75 NGVD                 |
| Gates:           | None                              |
| U/S Channel:     | Deer Head Lake                    |
| D/S Channel:     | Natural Channels                  |

j. Regulating Outlets

|                   |   |
|-------------------|---|
| Low level outlet: | 72-inch C.M.P.                                  |
| Controls:         | 2-sets of timber stop planks-<br>3 ft x 7.5 ft. |
| Emergency gate:   | None  |
| Outlet:           | 14 NGVD   |

## SECTION 2

### 2. ENGINEERING DATA

#### 2.1 Design

One drawing showing the new drop inlet for Deer Head Lake Dam, before the size of the discharge pipe was revised and a sketch of the concrete weir are available in the files of the N.J. Department of Environmental Protection (NJ-DEP) in Trenton. No embankment data from soil borings, soil tests, design computations, or other geotechnical data are available to assess the stability properly. Data concerning the hydraulic capacity of the present spillways is also unavailable.

#### 2.2 Construction

Data is not available concerning the as-built construction of the dam. No data exists of construction methods, borrow sources or other data pertinent to the construction of the dam.

#### 2.3 Operation

Formal operation records are not kept for the dam and reservoir. The lake is allowed to operate naturally without regulation.

#### 2.4 Evaluation

##### a. Availability

The availability of engineering data is poor. The stated plans concerning the dam are available from the NJ-DEP.

##### b. Adequacy

The engineering data available from the plans and from the field was adequate to perform hydrologic and hydraulic computations. The data was insufficient to perform stability analysis, but a preliminary evaluation could be made based on visual observations.

##### c. Validity

The information contained in the drawings and checked by limited field measurements appears to be valid, except that the discharge pipe from the timber drop inlet is 72-inches instead of 40-inches as shown on the plans.

## SECTION 3

### 3. VISUAL INSPECTION

#### 3.1 Findings

##### a. General

The visual inspection of Deer Head Lake Dam revealed the dam and spillways to be in good condition. At the time of the inspection the lake level was just above the crest of the concrete weir at the left end of the dam.

##### b. Dam

The earth embankment appears to be sound. No surface cracking on the embankment was noted. Some erosion due to rainfall runoff was observed in the parking area and on the left bank of the downstream channel between the old and new bridges. The vertical alignment of the crest is good. The horizontal alignment is very irregular due to the filling in on both sides of the original crest. The paved roadway is in good condition. There are telephone poles along the upstream crest between the road and the beach. No evidence of seepage or of burrowing by animals was observed.

##### c. Appurtenant Structures

##### 1. Spillways

The concrete weir spillway at the left end on the dam is in good condition. The crest and downstream face are spalled. The discharge channel is heavily spalled and sections have cracked and settled. The timber drop inlet at the right end of the dam is in good condition. The horizontal and vertical alignments of both spillways appeared good.

##### 2. Outlet Works

The outlet works for the dam consist of the drop inlet with the two sets of manually removable stop planks attached to the upstream face of the inlet and a 72-inch corrugated metal pipe that discharges the flow into the downstream channel. The inlet end of the pipe has a timber headwall, the outlet end has a concrete headwall, both are in good condition. The outlet of the pipe has approximately 1.5 feet of sediment in the bottom.

### 3. Reservoir Area

The side slopes of the reservoir are flat and wooded with houses along the shore. There is no indication of slope instability.

### 4. Downstream Channel

There are two separate downstream channels. The channel for the drop inlet is narrow with some debris on the bottom. The slopes are fairly flat, shallow and heavily wooded. There are houses along the right approximately 150 feet from the channel. The downstream channel for the concrete weir starts at the end of the discharge apron and goes under the new bridge into a wide channel, that becomes very irregular with many little islands and trees further downstream. The junction of the channel and apron has scoured exposing the apron cut-off wall and the timber pilings for the abutments of the old bridge. Both downstream channels eventually, flow into Lake Barnegat approximately 1,400 feet downstream of the dam.



## SECTION 4

### 4. OPERATIONAL PROCEDURES

#### 4.1 Procedures

Deer Head Lake Dam is used to impound water for recreational activities. The level of the lake is maintained through the unregulated flow over the spillways. The lake is lowered occasionally to clean the lake bottom and make repairs.

#### 4.2 Maintenance of the Dam

There is no regular inspection and maintenance program for the dam and appurtenant structures. Lacey Township is responsible for the maintenance of the dam.

#### 4.3 Maintenance of Operating Facilities

The low-level outlet operating facilities consist of two sets of manually removable timber stop planks three foot long.

#### 4.4 Evaluation

The present operation and maintenance procedures are fair with the dam and spillways being maintained in a serviceable condition.

## SECTION 5

### 5. HYDRAULIC/HYDROLOGIC

#### 5.1 Evaluation of Features

##### a. Design

The drainage area above Deer Head Lake Dam is approximately 13.8 square miles. A drainage map of the water shed of the dam site is presented on Plate 1, Appendix D.

The topography within the basin is generally moderately sloped. Elevations range from approximately 184 feet above NGVD at the south end of the watershed to about 25 feet at the dam site. Land use patterns within the watershed are mostly woodland and swamp with some residential development around the lake area.

The evaluation of the hydraulic and hydrologic features of the dam was based on criteria set forth in the Corps guidelines and additional guidance provided by the Philadelphia District, Corps of Engineers. The SDF for the Dam falls in a range of 1/2 PMF to PMF. In this case, the low end of the range, 1/2 PMF, is chosen since the factors used to select size and hazard classification are on the low-side of their respective ranges.

The Probable Maximum Flood (PMF) was calculated from the probable maximum precipitation using Hydrometeorological Report No. 33 with standard reduction factors. A unit hydrograph supplied by the Philadelphia District, Corps of Engineers, was used for Deer Head Lake Dam.

Initial and constant infiltration loss rates were applied to the Probable Maximum Precipitation to obtain rainfall excesses. The rainfall excesses were applied to the unit hydrograph to obtain the PMF and various ratios of PMF utilizing program HEC-1-DB.

The SDF peak outflow calculated for the dam is 9,037 cfs. This value is derived from the half PMF, and results in overtopping of the dam, assuming that the lake was originally at the spillway crest elevations.

The stage-outflow relation for the spillway was determined from the geometry of the spillway and dam, utilizing HEC-1 Dam Safety Version program.

The reservoir stage-storage capacity relationship was computed directly by the conic method, utilizing the HEC-1-DB program. The reservoir surface area at various elevations were measured by planimeter from a U.S.G.S. Quadrangle topographic map. Reservoir storage capacity included surcharge levels exceeding the top of the dam, and the spillway rating curve was based

on the assumption that the dam remains intact during routing. The spillway rating curve is presented in the Hydrologic Computation, Appendix D.

A breach analysis indicates that the stage of the stream 1,600 feet downstream of the dam is 0.7 feet higher, due to dam failure from overtopping at 0.1 PMF than it would be without failure at 0.1 PMF. This is likely not to jeopardize the development downstream significantly more than without failure. The discharge facility is thus rated "inadequate".

Drawdown calculations indicate that to empty the lake to an elevation of 16.0 NGVD through the two low-level outlets would take 4.5 hours, assuming a 2 cfs/square mile inflow. This is not considered to be an excessive drawdown period.

b. Experience Data

No records of reservoir stage or spillway discharge are maintained for this site.

c. Visual Observation

There are two separate downstream channels that eventually flow into Lake Barnegat approximately 1,400 feet downstream of the dam. The channel for the right spillway is narrow with some debris near the outlet. The slopes are fairly shallow, flat and heavily wooded. There are houses approximately 150 feet from the channel on the right. The channel for the left spillway is wide until beyond the new bridge where it becomes very irregular with many little islands and trees in the middle.

The side slopes of the reservoir are flat and do not exhibit signs of instability. The drainage area is wooded and moderately sloped.

d. Overtopping Potential

A storm of magnitude equivalent to the SDF would cause overtopping of the dam to a height of 2.55 feet. Computations indicate that the dam can pass approximately 3.7 percent of the PMF without overtopping the dam crest. Since the 1/2 PMF is the Spillway Design Flood (SDF) for this dam, according to the Recommended Guidelines for Safety Inspection of Dams by the Corps of Engineers, the spillway capacity of the dam is assessed as "inadequate".

## SECTION 6

### 6. STRUCTURAL STABILITY

#### 6.1 Evaluation of Structural Stability

##### a. Visual Observations

There are no signs of distress in the embankment of Deer Head Lake Dam. The left spillway's downstream channel is eroded at the junction of the discharge apron, exposing the cut-off wall and the timber pilings of the abutments for the old bridge. In addition, sections of the concrete discharge apron have cracked and settled. The concrete weir is in good condition except for spalling across the crest and downstream face. The drop inlet spillway at the right end of the dam is in good condition.

##### b. Design and Construction Data

No design computations relating to stability were uncovered during the report preparation phase. No embankment or foundation soil parameters are available for carrying out a conventional stability analysis of the embankment.

##### c. Operating Records

No operating records are available relating to the stability of the dam.

##### d. Post-Construction Changes

Post construction changes are as described in Section 1.2g.

##### e. Static Stability

A static stability analysis was not performed for Deer Head Lake Dam because the lack of data on which to base assumptions of material properties within embankment zones might produce misleading results, but based on the findings of the visual inspection, the preliminary assessment of static stability is that it is satisfactory.

##### f. Seismic Stability

The dam is located in Seismic Zone 1, as defined in Recommended Guidelines for Safety Inspection of Dams, prepared by the Corps of Engineers. In general, projects located in Seismic Zones 0, 1 and 2 may be assumed to present no hazard from earthquake, provided the static stability conditions are satisfactory and conventional safety margins exist, and based on the findings of the visual inspection, the preliminary assessment of the static and seismic stabilities is that they are satisfactory.

## SECTION 7

### 7. ASSESSMENT/REMEDIAL MEASURES

#### 7.1 Dam Assessment

##### a. Safety

The dam has been inspected visually and a review has been made of the available engineering data. This assessment is subject to the limitations inherent in the visual inspection procedures stipulated by the Corps of Engineers for a Phase I report.

Deer Head Lake Dam is inadequate because the dam does not have the spillway capacity to pass the SDF, one half of the PMF, without overtopping. Overtopping of the dam carries with it the danger of a possible progressive failure of the dam. The present spillway capacity of the dam is approximately 3.7 percent of the PMF.

No definitive statement pertaining to the safety of the embankment can be made without acquisition of embankment material engineering properties, but based on the findings of the visual inspection, preliminary assessment of the static stability is that it is satisfactory.

##### b. Adequacy of Information

The information uncovered was adequate to perform hydrologic and hydraulic computations. The data was insufficient to perform even an approximate computation of the stability of the dam. A preliminary assessment of the dam could be made by visual observation only.

##### c. Urgency

The remedial measures and recommended actions along with a timetable for their completion are detailed below. All recommended action should be conducted under the supervision of an engineer who is experienced in the design, construction and inspection of dams.

#### 7.2 Remedial Measures

##### a. Alternatives for Increasing Spillway Capacity

Alternatives for increasing spillway capacity are as follows:

1. Increase the embankment height of the dam thus permitting a higher discharge to pass.

2. Lower the spillway crest elevation.
3. Increase the effective spillway crest length.
4. A combination of any of the above alternatives.

b. Recommendations

1. Carry out a more precise hydrologic and hydraulic analysis of the dam within twelve months, to determine the need and type of mitigating measures necessary. If required, conduct a study of the means of increasing spillway discharge capacity and develop alternative schemes for construction. This should include the installation of headwater and tailwater gages. The ability of the dam to withstand overtopping should also be studied.
2. Repair stilling basin of left spillway with epoxy cement within twelve months.
3. Repair concrete surfaces of left spillway with epoxy cement within twelve months.
4. Fill in eroded section of channel at discharge apron of the left spillway with appropriate material and then riprap channel bottom to prevent future erosion. This work should be completed within twelve months.
5. Clean out sediment from the outlet end of the discharge pipe and immediately downstream of the outlet within twelve months.
6. Fill in eroded areas of embankment with appropriate material within twelve months.

The following additional actions are recommended:

1. The owner should develop an emergency action plan (if one is not already available) outlining actions to be taken by the operator to minimize downstream effects of an emergency and establish a flood warning system for the downstream communities within three months.
2. Conduct a complete topographic survey of the dam and surrounding area, in order to develop a detailed plan and several cross-sections of the dam. Annotate and update the existing drawings, and form a coherent as-built set.

c. O & M Procedures

The owner should develop, within one (1) year after formal approval of the report, written operating procedures and a periodic maintenance plan to insure the safety of the dam.

P L A T E S

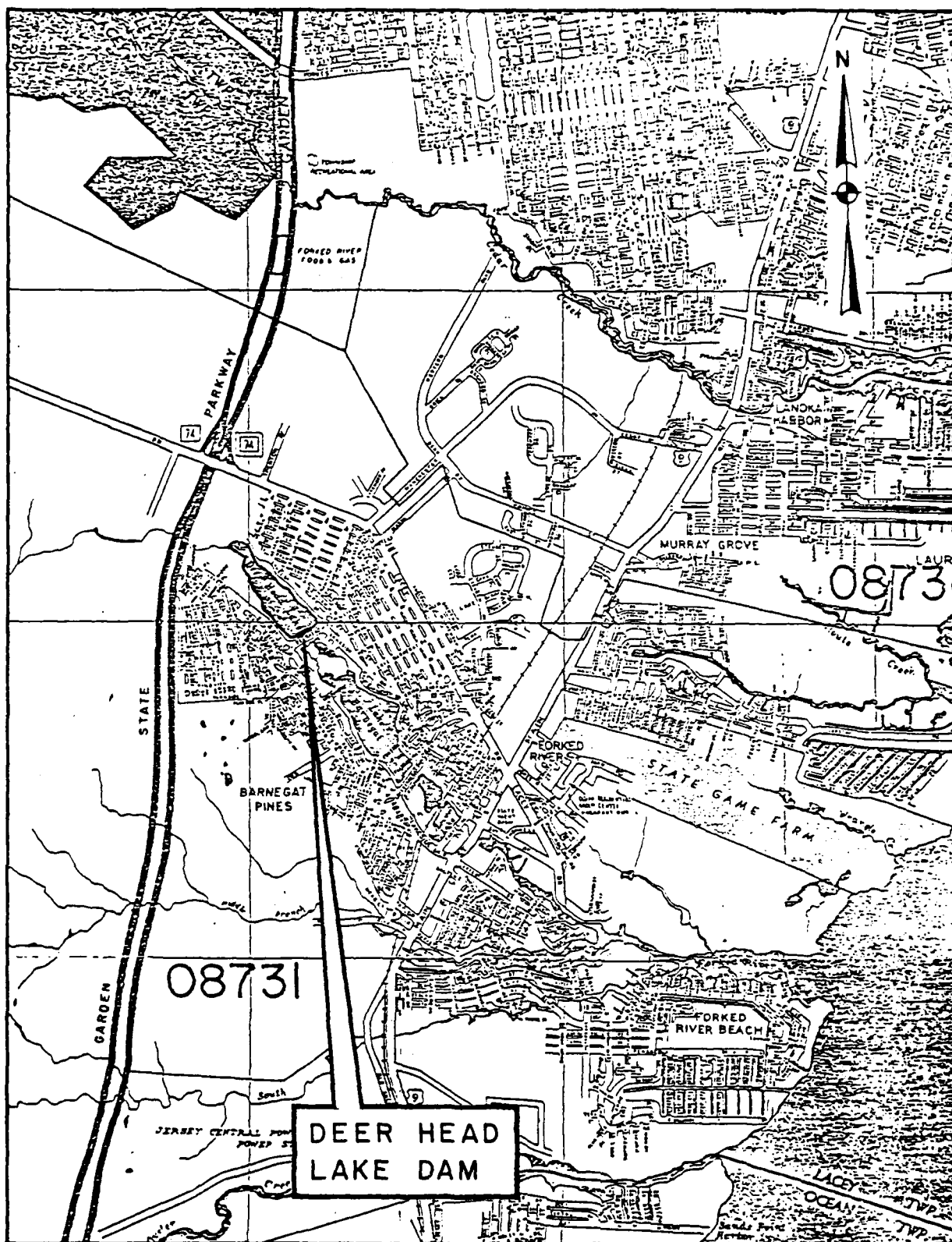


DEER HEAD LAKE DAM  
LACEY TOWNSHIP  
OCEAN COUNTY, N. J.



KEY MAP

PLATE I

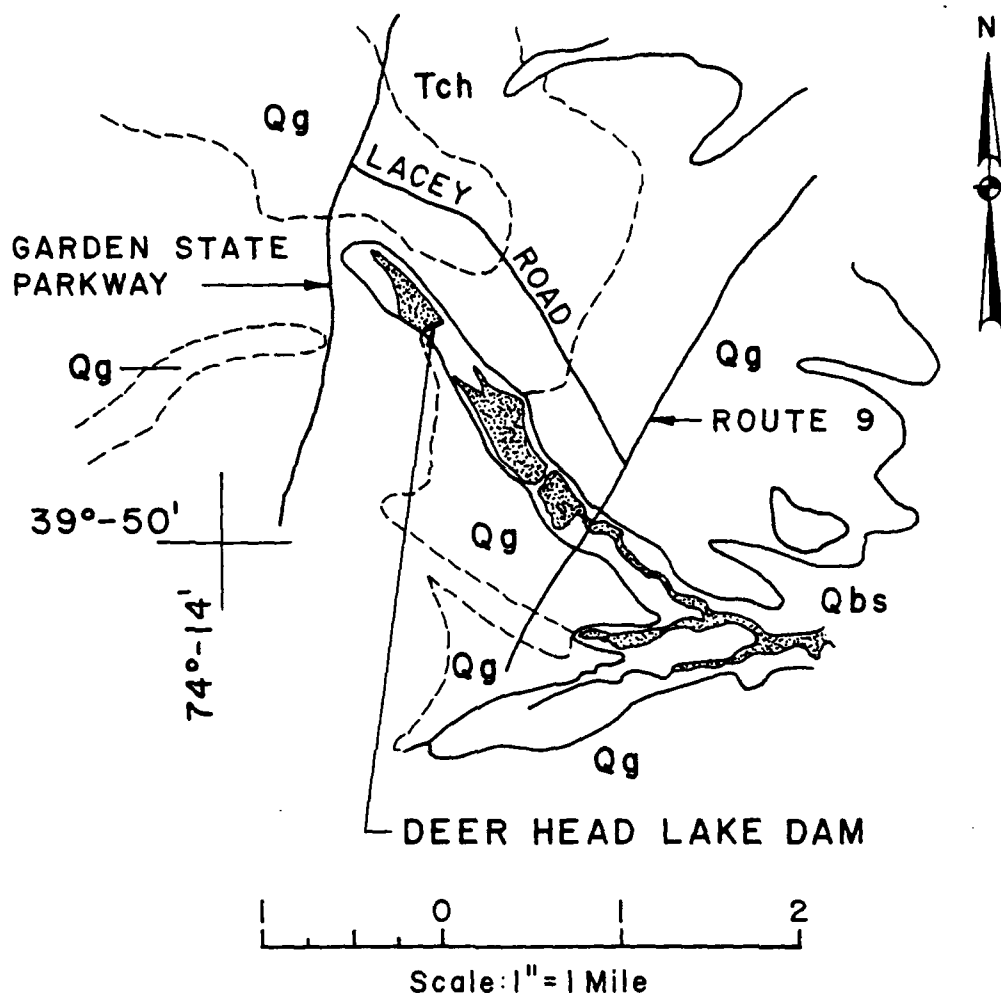


Scale in Feet (Approx.)

|       |   |       |       |        |
|-------|---|-------|-------|--------|
| 4,000 | 0 | 4,000 | 8,000 | 12,000 |
|-------|---|-------|-------|--------|

VICINITY MAP

PLATE 2



## LEGEND

### QUATERNARY

Qbs Beach Sand

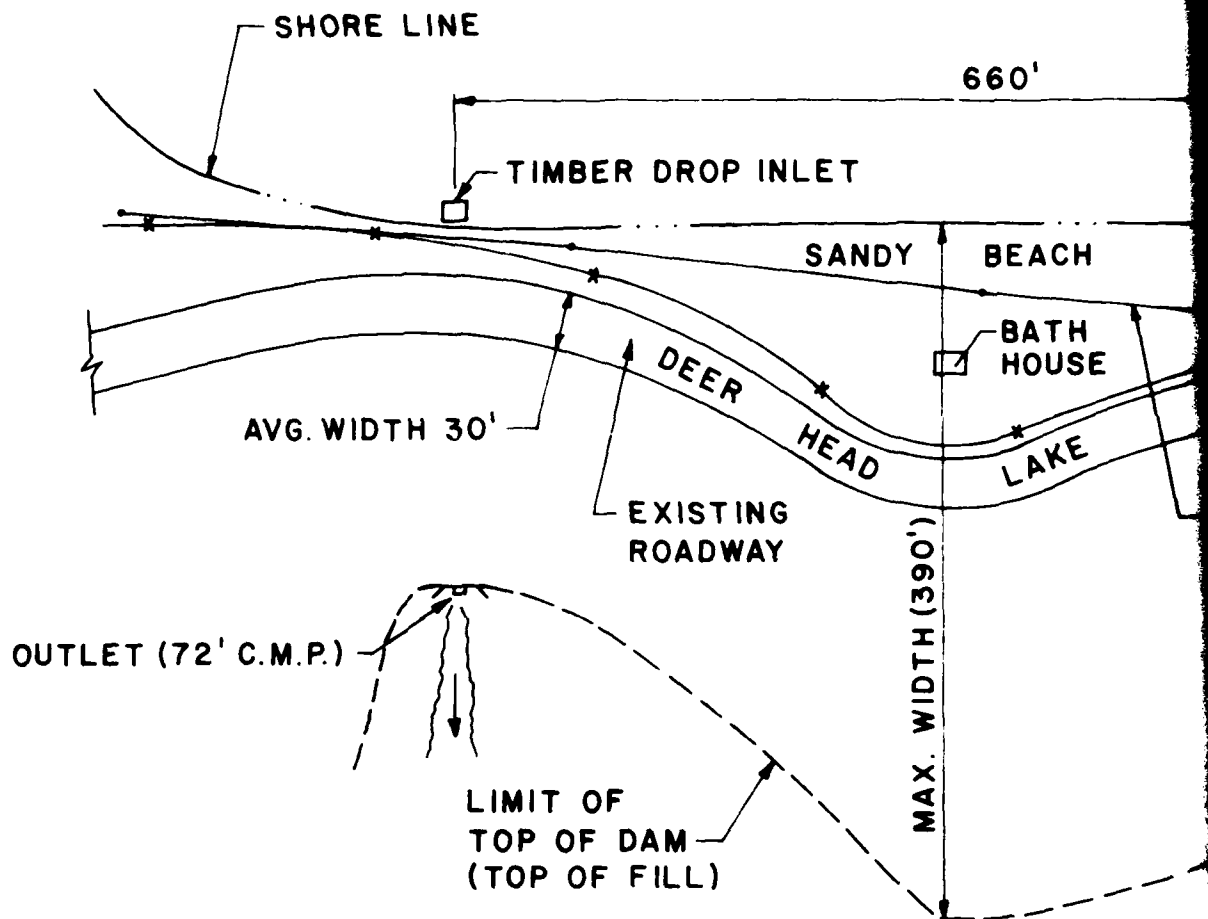
Qg Gravel

### TERTIARY

Tch Cohansey Sand

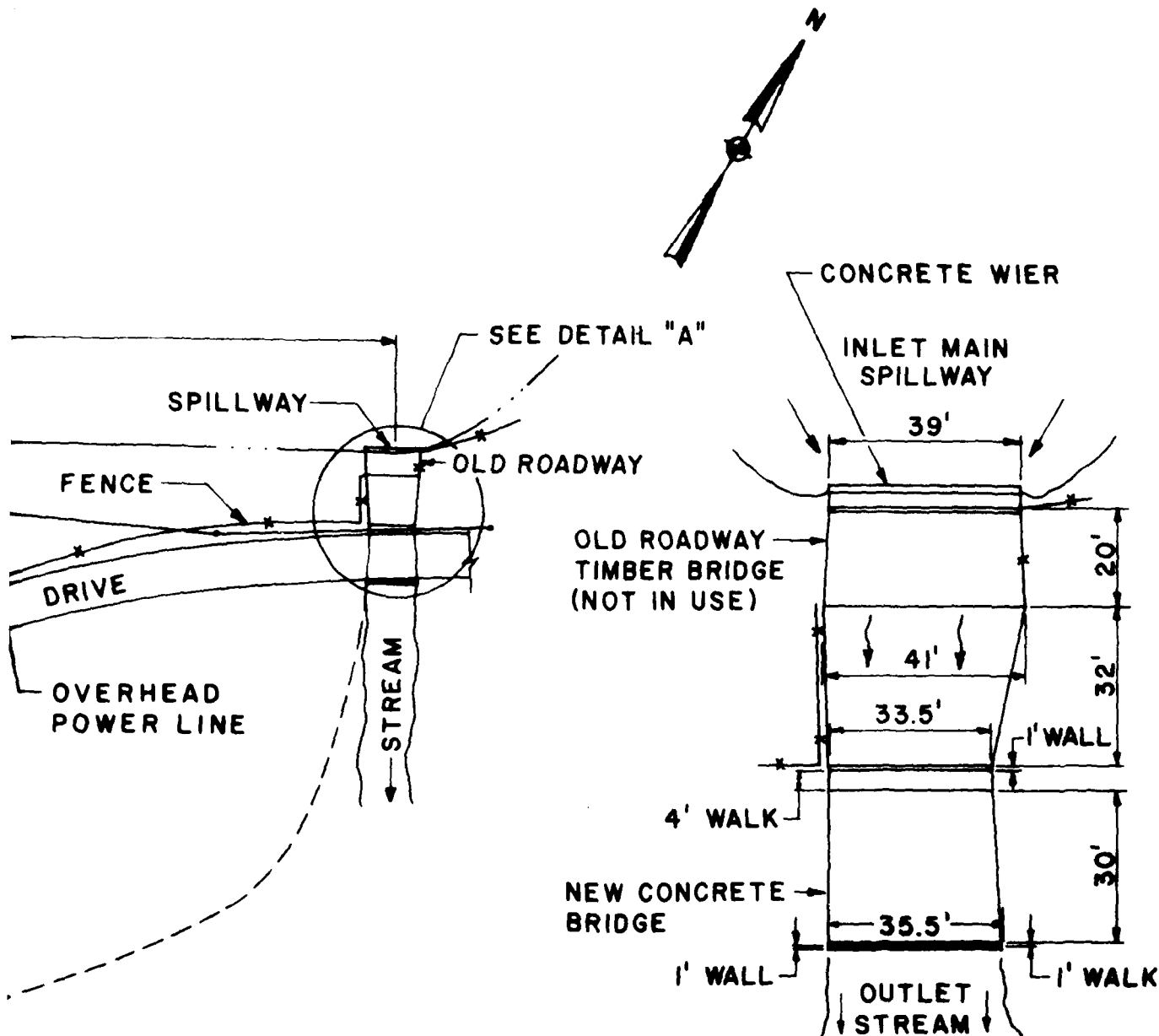
## GEOLOGIC MAP DEER HEAD LAKE DAM

# DEER HEAD LAKE



PLAN

SCALE: 1" = 100'



### DETAIL "A"

SCALE: 1" = 30'

DEER HEAD LAKE DAM  
LACEY TOWNSHIP, OCEAN COUNTY, N.J.

SKETCH OF PLAN  
PREPARED FROM FIELD NOTES TAKEN  
DURING INSPECTION ON JAN. 14, 1981

BY:  
HARRIS-ECI ASSOCIATES  
WOODBRIIDGE, N.J.

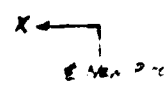
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DATE: FEB. 1981  
SHEET: 1 OF 1

PLATE

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Dist 9.1.50

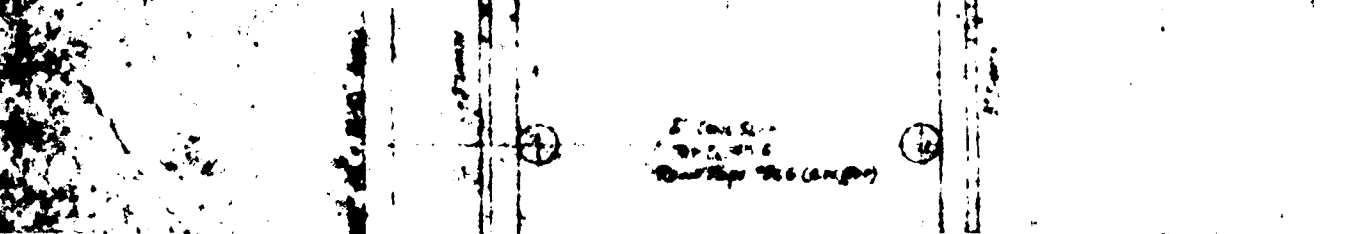
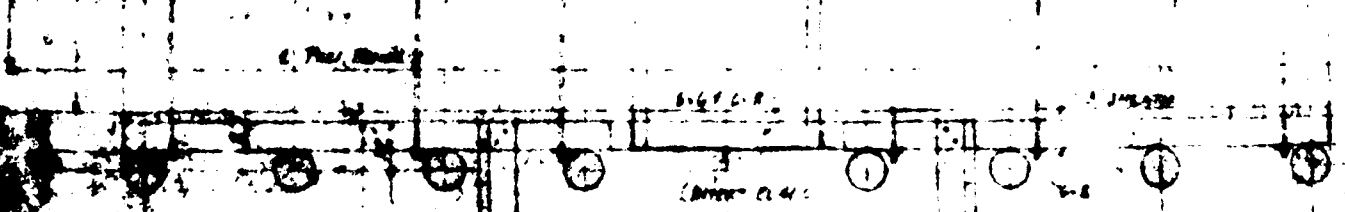
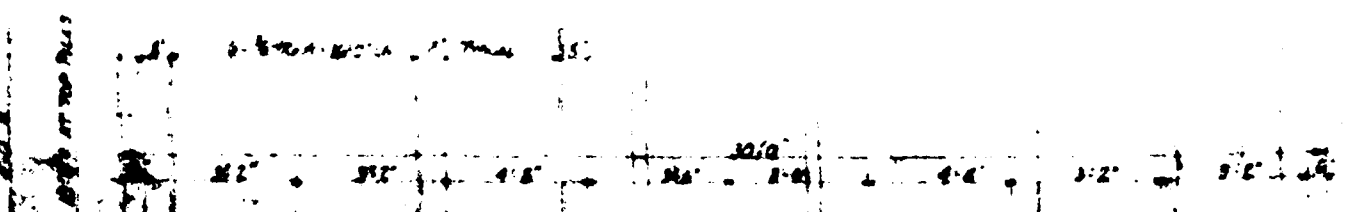
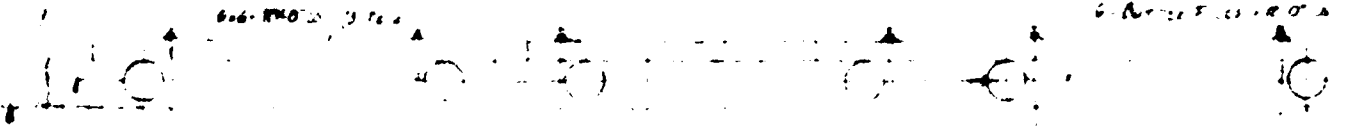
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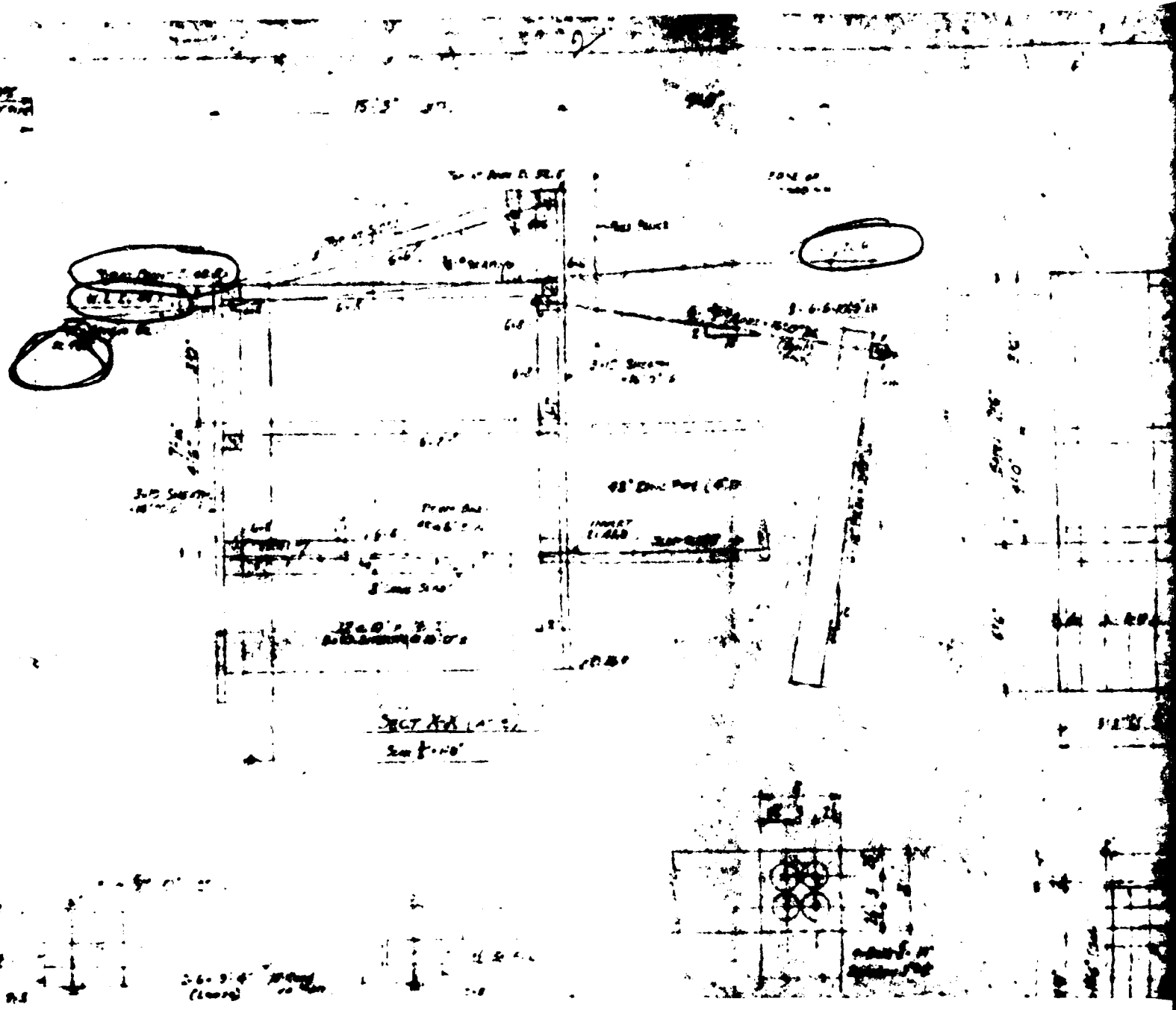
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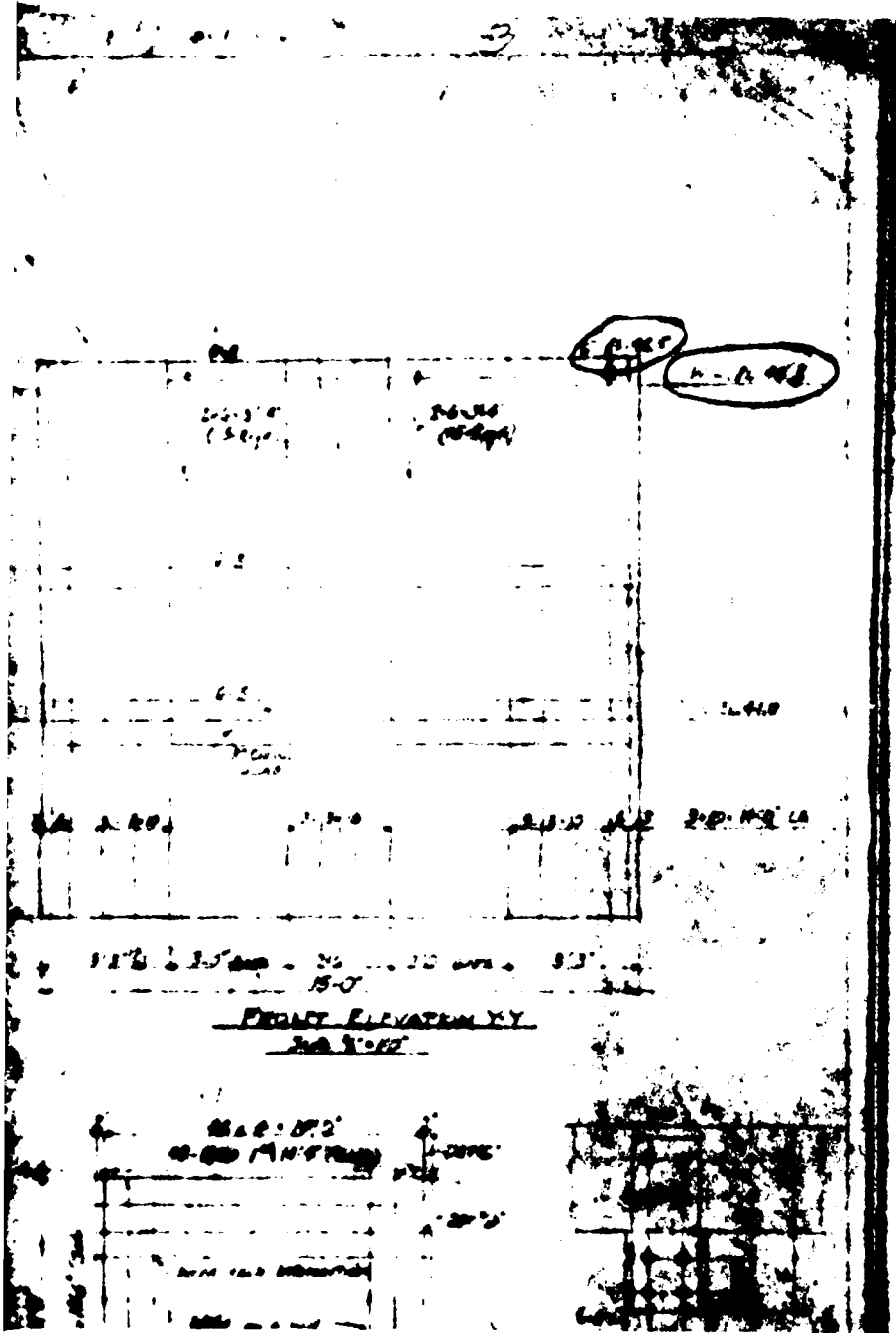
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6.10.10.10.10.10

Notes 5.1.1.1.1.1.1

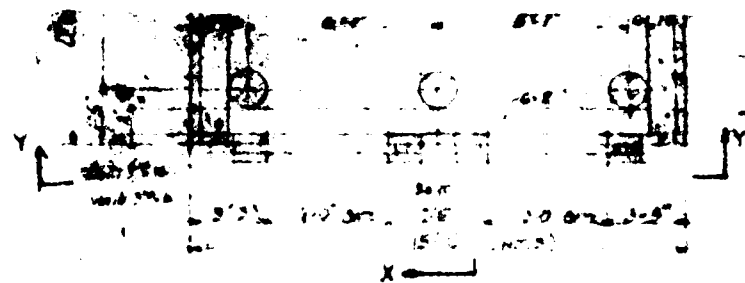


Notes 6.1.1.1.1.1.1  
Notes 7.1.1.1.1.1.1  
Notes 8.1.1.1.1.1.1

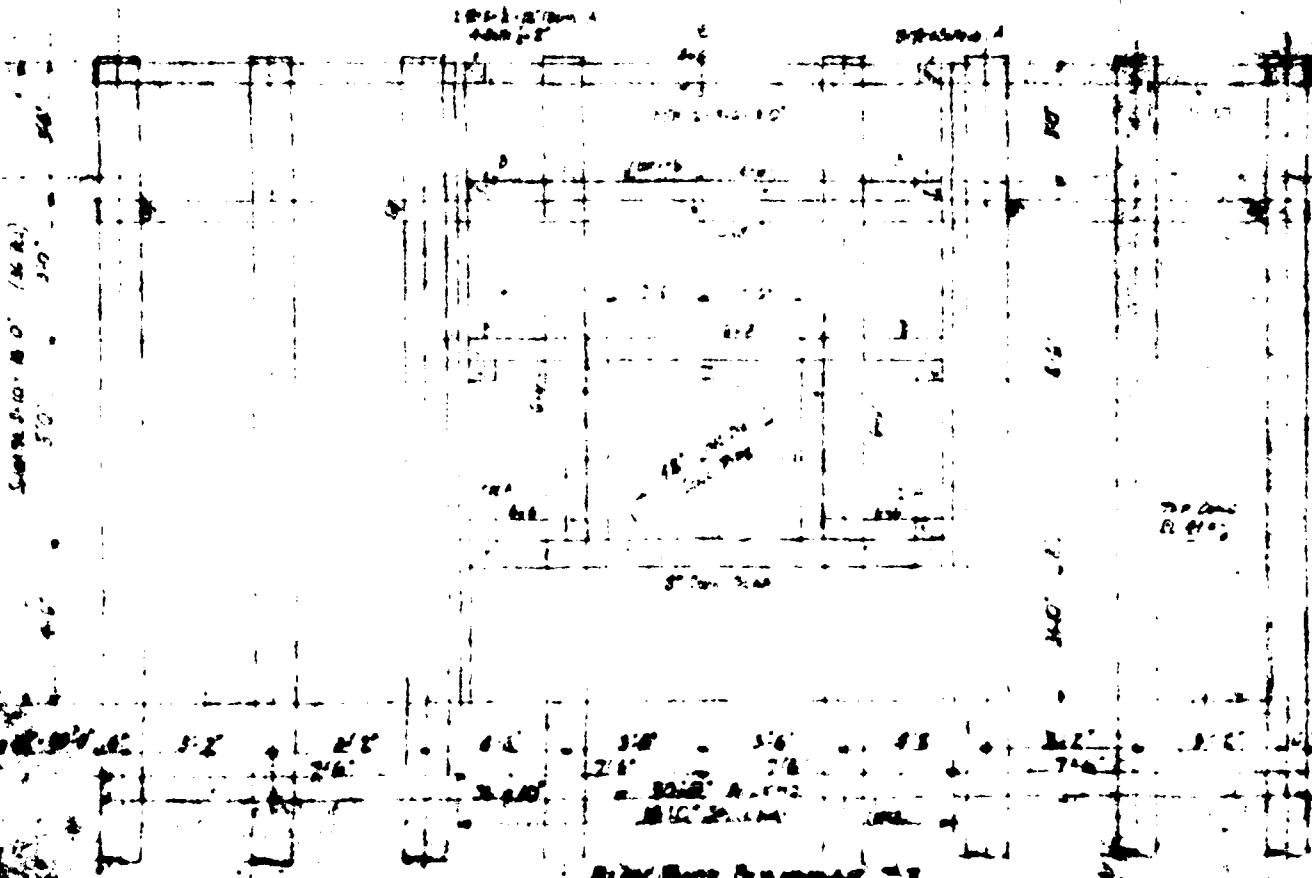




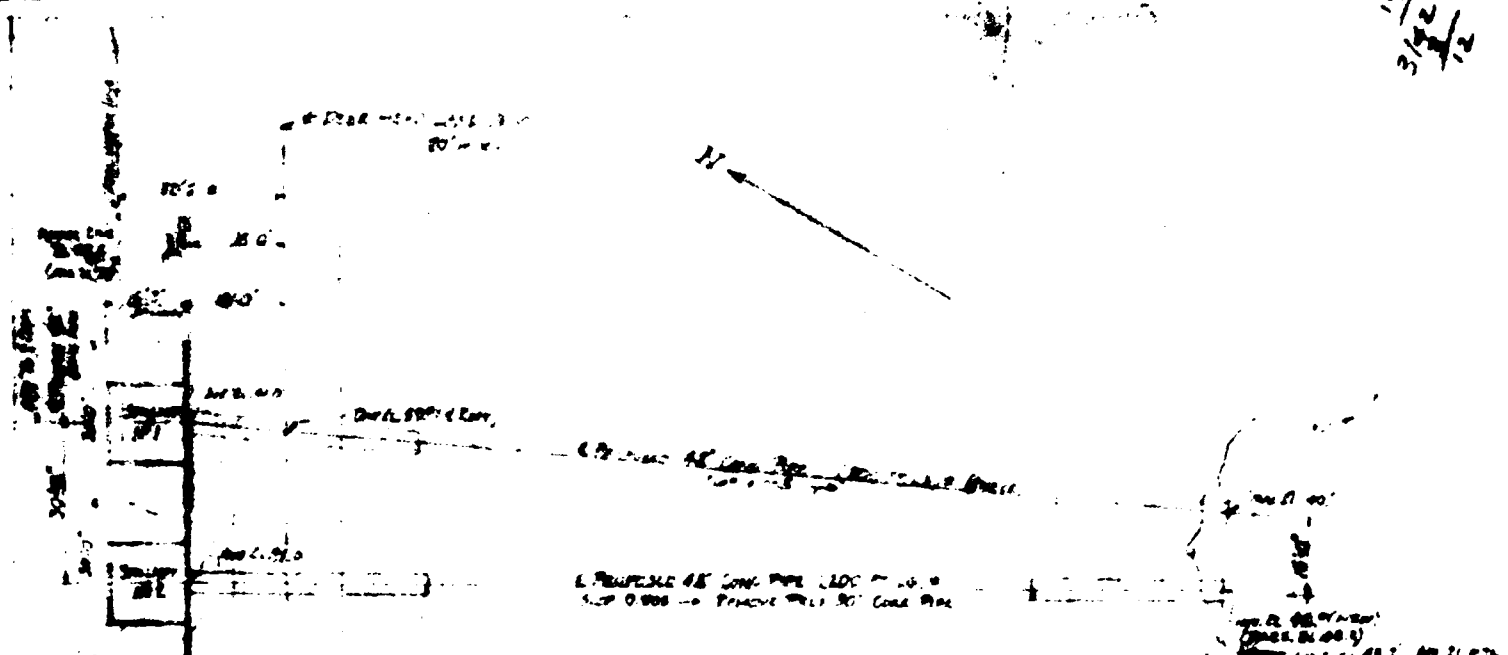
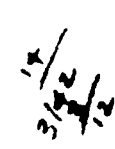




Plan of Tank  
Scale 1" = 10'  
Plan of Tank  
Scale 1" = 10'



**W. B. E. D.**



Jan 1981

DETAILS OF SETTING (2 REA)  
 JUNE 27, 1964



NOTE

ALL CONCRETE 2,000 PSI  
 ALL TIES 1/2" DIA. ASPHALT  
 ALL WINDER DIA. 1/2" (STEEL) (WINDER) 1/2" DIA  
 1. POINT TIE TIE TIE TIE TIE TIE TIE TIE TIE TIE  
 ALL PIER NO. 100 (YELLOW TIE TIE TIE TIE TIE TIE TIE TIE TIE TIE)  
 CONC TIE ASPHALT 1/2" DIA (STEEL) (WINDER) 1/2" DIA  
 (1/2" DIA CONC) (STEEL) (WINDER) 1/2" DIA  
 SEE SPEC FOR SETTING

SALE ALL WINDER 1/2" DIA (STEEL) (WINDER) 1/2" DIA

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APPENDIX A

CHECK LIST - VISUAL OBSERVATIONS

CHECK LIST - ENGINEERING, CONSTRUCTION  
MAINTENANCE DATA

CHECK LIST  
VISUAL INSPECTION

PHASE 1

Name Dam Deer Head Lake Dam County Ocean State New Jersey Coordinators NJ-DEP

Date(s) Inspection January 14, 1981 Weather Partly Cloudy Temperature 25°F  
February 15, 1981 Partly Cloudy 45°F

Pool Elevation at Time of Inspection 22.5 NGVD Tailwater at Time of Inspection 14.5 NGVD

Inspection Personnel:

January 14, 1981

William Birch  
Thomas Moroney  
Joseph Sirianni (Recorder)

February 15, 1981

Joseph Sirianni

OWNER/REPRESENTATIVE:

# EMBANKMENT

| VISUAL EXAMINATION OF  | OBSERVATIONS | REMARKS AND RECOMMENDATIONS                     |
|--|--------------|---|
| SURFACE CRACKS   |              |   |
| None noticed.  |              |   |
| UNUSUAL MOVEMENT OR CRACKING AT OR BEYOND THE TOE.   |              |   |
| None noticed.  |              |   |
| SLOUGHING OR EROSION OF EMBANKMENT AND ABUTMENT SLOPES   |              |   |
| Some erosion in parking area and on left bank between the old and new bridges.<br>Erosion due to rainfall runoff.  |              | Fill in eroded areas with appropriate material. |
| VERTICAL & HORIZONTAL ALIGNMENT OF THE CREST   |              |   |
| Vertical alignment appeared good. Horizontal alignment very irregular due to upstream and downstream areas of original dam being filled in for a beach, and a parking lot. |              |   |
| RIPRAP FAILURES  |              |   |
| None.  |              |   |

# EMBANKMENT

| VISUAL EXAMINATION OF<br>EARTH EMBANKMENT             | OBSERVATIONS  | REMARKS AND RECOMMENDATIONS |
|---|---|-----------------------------|
|   | There is a paved roadway on the crest. The downstream area has been filled in with sand & gravel for a parking lot and the upstream area with beach sand. There are telephone poles along the upstream crest of the embankment. |                             |
| JUNCTION OF EMBANKMENT AND ABUTMENT, SPILLWAY AND DAM | Good condition.   |                             |
| ANY NOTICEABLE SEEPAGE                                | None observed.  |                             |
| STAFF GAGE AND RECORDER                               | None.   |                             |
| DRAINS  | None.   |                             |

# OUTLET WORKS

| VISUAL EXAMINATION OF                                      | OBSERVATIONS  | REMARKS AND RECOMMENDATIONS   |
|--|---|---|
| CRACKING & SPALLING OF CONCRETE SURFACES IN STILLING BASIN |   |   |
|  | <p>Stilling basin for concrete weir left spillway has sections that have cracked and settled, surface is heavily spalled.</p> <p>N/A to drop inlet spillway at the right end of dam.</p>  | <p>Repair stilling basin with epoxy cement.</p>                                 |
| INTAKE STRUCTURE   |   |   |
|  | <p>Right spillway is a drop inlet with a steel bar grate, two sets of timber stop planks and is in good condition.</p> <p>N/A to concrete weir spillway.</p>  |   |
| OUTLET STRUCTURE   |   |   |
|  | <p>72-inch corrugated metal pipe is the outlet from the drop inlet. There is a timber headwall at the inlet end and a concrete headwall at the outlet end of pipe. Both are in good condition. There is 1.5 feet of sediment in pipe at the outlet.</p> | <p>Clean out sediment from pipe and immediately downstream from the outlet.</p> |
| OUTLET FACILITIES  |   |   |
|  | <p>None.</p>  |   |
| EMERGENCY GATE   |   |   |
|  | <p>None.</p>  |   |



# UNGATED SPILLWAY

| VISUAL EXAMINATION OF   | REMARKS AND RECOMMENDATIONS   |
|---|---|
| <p>CONCRETE WEIR</p> <p>Left spillway is a concrete weir. The crest and downstream face are spalled.</p> <p>Right spillway is a timber drop inlet.</p>  | <p>Repair spalled concrete with epoxy cement.</p>   |
| <p>APPROACH CHANNEL</p> <p>Lake is the approach channel for both spillways.</p>   |   |
| <p>DISCHARGE CHANNEL</p> <p>Left spillway discharges into natural channel. Junction of channel and discharge apron has eroded exposing the apron cut-off wall and the piling of the abutments of the old bridge.</p> <p>Right spillway discharges into 72-inch C.M.P. Pipe has 1.5 feet of sedimentation in bottom.</p> | <p>Fill in the eroded area with suitable material and riprap channel bottom to prevent future erosion.</p> <p>Clean out sediment from 72-inch pipe.</p> |
| <p>BRIDGE AND PIERS</p> <p>Timber bridge over left spillway stilling basin, has timber piling piers into concrete apron. Timber is deteriorating.</p>   |   |

# INSTRUMENTATION

| VISUAL EXAMINATION OF<br>MONUMENTATION/SURVEYS | OBSERVATIONS | REMARKS AND RECOMMENDATIONS |
|--|--------------|-----------------------------|
| None.  |              |                             |
| OBSERVATION WELLS                              |              |                             |
| None.  |              |                             |
| WEIRS  |              |                             |
| None.  |              |                             |
| PIEZOMETERS                                    |              |                             |
| None.  |              |                             |
| OTHER  |              |                             |
| None.  |              |                             |

# RESERVOIR

| VISUAL EXAMINATION OF | OBSERVATIONS   | REMARKS AND RECOMMENDATIONS |
|-----------------------|--|-----------------------------|
| SLOPES                | Flat and wooded with scattered houses. No indication of slope instability. |                             |
| SEDIMENTATION         | None visible.  |                             |
|                       |  |                             |
|                       |  |                             |
|                       |  |                             |

# DOWNSTREAM CHANNEL

| VISUAL EXAMINATION OF                      | OBSERVATIONS  | REMARKS AND RECOMMENDATIONS |
|--|---|-----------------------------|
| CONDITION (OBSTRUCTIONS, DEBRIS, ETC.)     | <p>The channel for the left spillway is wide until downstream of the new bridge, then the width becomes very irregular with small islands and trees in the middle. The channel for the right spillway is narrow with some minor debris on the bottom.</p> |                             |
| SLOPES                                     | <p>The slopes for both channels are shallow, fairly flat and heavily wooded.</p>  |                             |
| APPROXIMATE NUMBER OF HOMES AND POPULATION | <p>Both channels flow into Lake Barnegat approximately 1,400 feet downstream. There are houses along the outside of both channels and along the shore of Lake Barnegat.</p>   |                             |
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CHECK LIST  
ENGINEERING DATA  
DESIGN, CONSTRUCTION, OPERATION

| ITEM                         | REMARKS  |
|------------------------------|--|
| PLAN OF DAM                  | None   |
| REGIONAL VICINITY MAP        | Available. Ocean County Map and U.S.G.S. Quadrangle sheet for Forked River, N.J. |
| CONSTRUCTION HISTORY         | No formal history exists, but can be deduced from available microfilm at NJ-DEP. |
| TYPICAL SECTIONS OF DAM      | None available.  |
| HYDROLOGIC/HYDRAULIC DATA    | Limited data available at NJ-DEP.  |
| OUTLETS - PLAN               | None available.  |
| - DETAILS                    | None available.  |
| - CONSTRAINTS                | None.  |
| - DISCHARGE RATINGS          | Not available.   |
| RAINFALL / RESERVOIR RECORDS | Not available.   |

CHECK LIST  
ENGINEERING DATA  
DESIGN, CONSTRUCTION, OPERATION  
(continued)

| ITEM                             | REMARKS  |
|----------------------------------|--|
| DESIGN REPORTS                   | None available.  |
| GEOLOGY REPORTS                  | Available U.S.G.S. Geologic Overlay Sheet for Ocean County and Engineering Soils Survey of New Jersey, Report No. 8 - Ocean County, by Rutgers University (New Brunswick, NJ). |
| DESIGN COMPUTATIONS              | Limited data available on microfilm, NJ-DEP.   |
| HYDROLOGY & HYDRAULICS           | None available.  |
| DAM STABILITY                    |  |
| SEEPAGE STUDIES                  |  |
| MATERIALS INVESTIGATIONS         |  |
| BORING RECORDS                   | None available.  |
| LABORATORY                       |  |
| FIELD                            |  |
| POST-CONSTRUCTION SURVEYS OF DAM | None.  |
| BORROW SOURCES                   | Unknown.   |
| SPILLWAY PLAN - SECTIONS         | Available on microfilm, NJ-DEP.  |
| - DETAILS                        |  |

CHECK LIST  
ENGINEERING DATA  
DESIGN, CONSTRUCTION, OPERATION  
(continued)

| ITEM  | REMARKS  |
|---|--|
| OPERATING EQUIPMENT<br>PLANS AND DETAILS                        | None.  |
| MONITORING SYSTEMS  | None available.  |
| MODIFICATIONS   | History of modifications to the original dam available on microfilm, NJ-DEP. |
| HIGH POOL RECORDS   | Not kept.  |
| POST CONSTRUCTION ENGINEERING<br>STUDIES AND REPORTS            | None   |
| PRIOR ACCIDENTS OF FAILURE<br>OF DAM - DESCRIPTION<br>- REPORTS | None known to exist.   |
| MAINTENANCE OPERATION<br>RECORDS                                | None known to exist.   |

APPENDIX B

PHOTOGRAPHS





Photo 1 - View of concrete weir left spillway looking towards the left end of the dam. (Photo taken January 14, 1981).

DEER HEAD LAKE DAM



Photo 2 - View of timber box spillway, looking toward the right end of the dam. (Photo taken January 14, 1981).

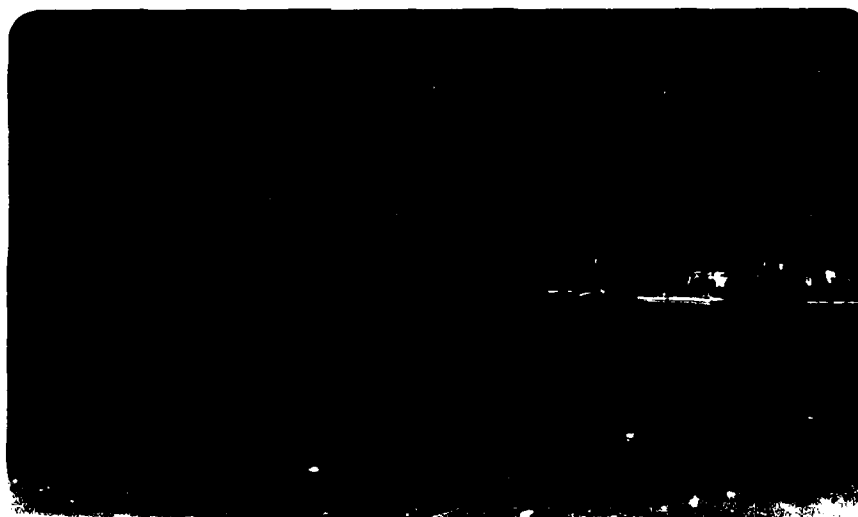


Photo 3 - View of Lake from beach area. (Photo taken February 15, 1981).



Photo 4 - View of downstream slope looking towards the left end of the dam. (Photo taken February 15, 1981).



Photo 5 - View of erosion on left bank of channel between the old and new bridges at the concrete weir spillway. (Photo taken January 14, 1981).

DEER HEAD LAKE DAM

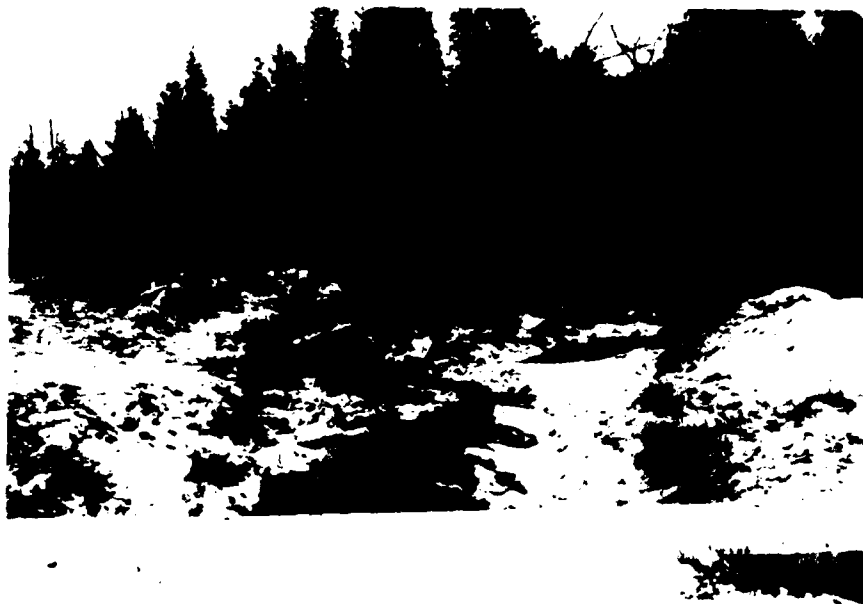


Photo 6 - View of downstream channel of timber box inlet at the right end of the dam. (Photo taken January 14, 1981).



Photo 7 - View of outlet end of 72-inch C.M.P. Note bottom of pipe is filled with sediment and debris. (Photo taken January 14, 1981).

DEER HEAD LAKE DAM



Photo 8 - View of downstream channel from end of the concrete weir discharge apron. (Photo taken January 14, 1981).

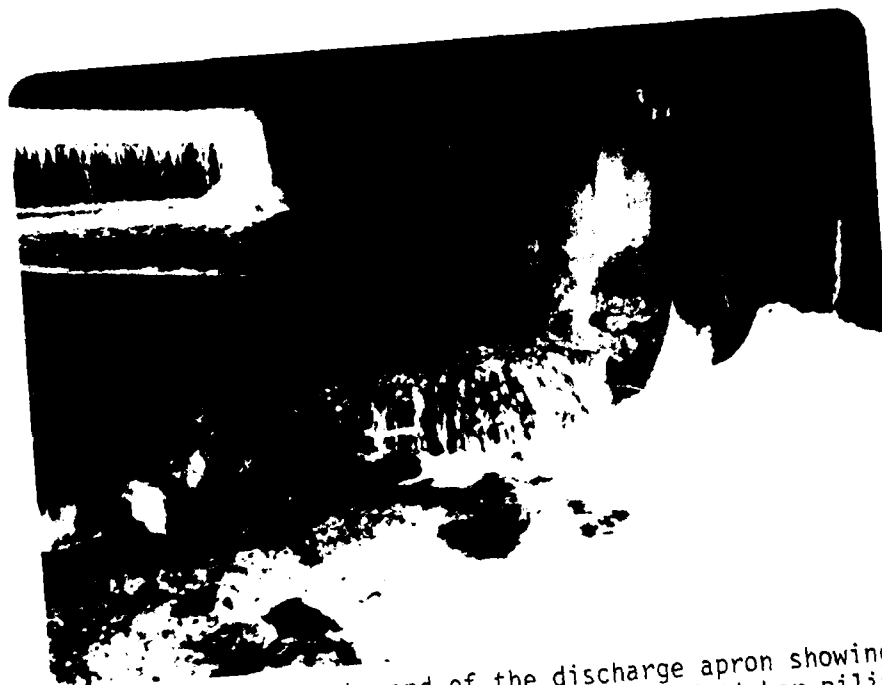


Photo 9 - View of the end of the discharge apron showing erosion exposing cut-off wall and timber piling. (Photo taken January 14, 1981).

DEER HEAD LAKE DAM

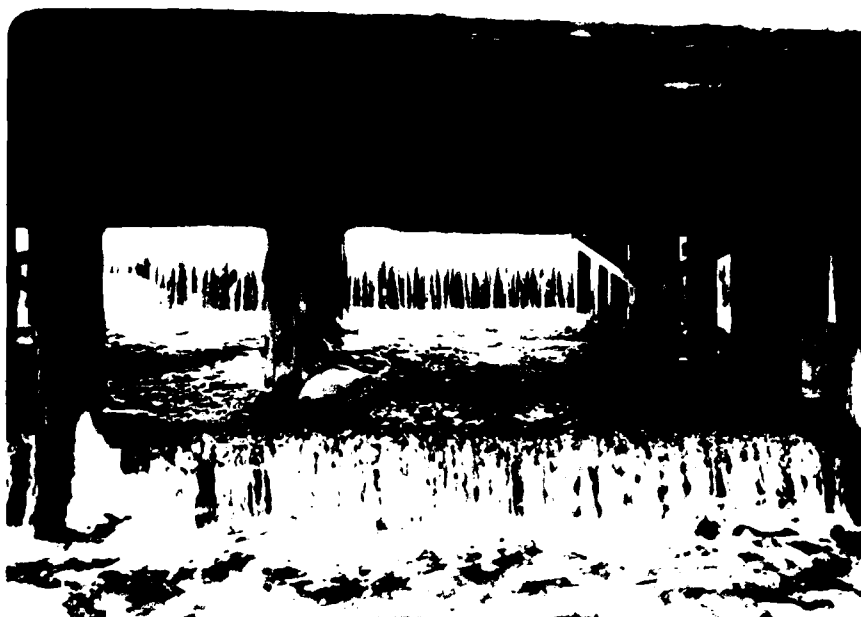


Photo 10 - View of concrete discharge apron showing the cracked and settled sections of the apron. (Photo taken January 14, 1981).



Photo 11 - Upstream view of concrete weir spillway taken from the left shoreline. (Photo taken January 14, 1981).

APPENDIX C

SUMMARY OF ENGINEERING DATA

CHECK LIST  
HYDROLOGIC AND HYDRAULIC DATA  
ENGINEERING DATA

Name of Dam: DEER HEAD LAKE DAM

Drainage Area Characteristics: 13.8 square miles

Elevation Top Normal Pool (Storage Capacity): 22.5 NGVD (48 acre-feet)

Elevation Top Flood Control Pool (Storage Capacity): N/A

Elevation Maximum Design Pool: 27.1 NGVD (SDFpool - 309 acre-feet)

Elevation Top Dam: 24.5 NGVD (132 acre-feet)

SPILLWAY CREST:

|                          |        |                             |
|--------------------------|--------|-----------------------------|
|                          | Left:  | 22.5 NGVD                   |
| a. Elevation             | Right: | 22.75 NGVD                  |
|                          | Left:  | Broad crested concrete weir |
| b. Type                  | Right: | Timber drop inlet           |
|                          | Left:  | 1 foot                      |
| c. Width                 | Right: | 13.5 feet                   |
|                          | Left:  | 39 feet                     |
| d. Length                | Right: | 41.5 feet                   |
|                          | Left:  | Entire length               |
| e. Location Spillover    | Right: | Both sides and front        |
| f. No. and Type of Gates |        | None                        |

OUTLET WORKS:

|                                   |  |
|-----------------------------------|--|
| a. Type                           | 2-3ft. x 7.5 ft. openings - 72-inch C.M.P. |
| b. Location                       | Upstream face of timber drop inlet         |
| c. Entrance Inverts               | 15 NGVD (Estimated)                        |
| d. Exit Inverts                   | 14 NGVD (Estimated)                        |
| e. Emergency Draindown Facilities | Timber stop planks                         |

HYDROMETEOROLOGICAL GAGES:

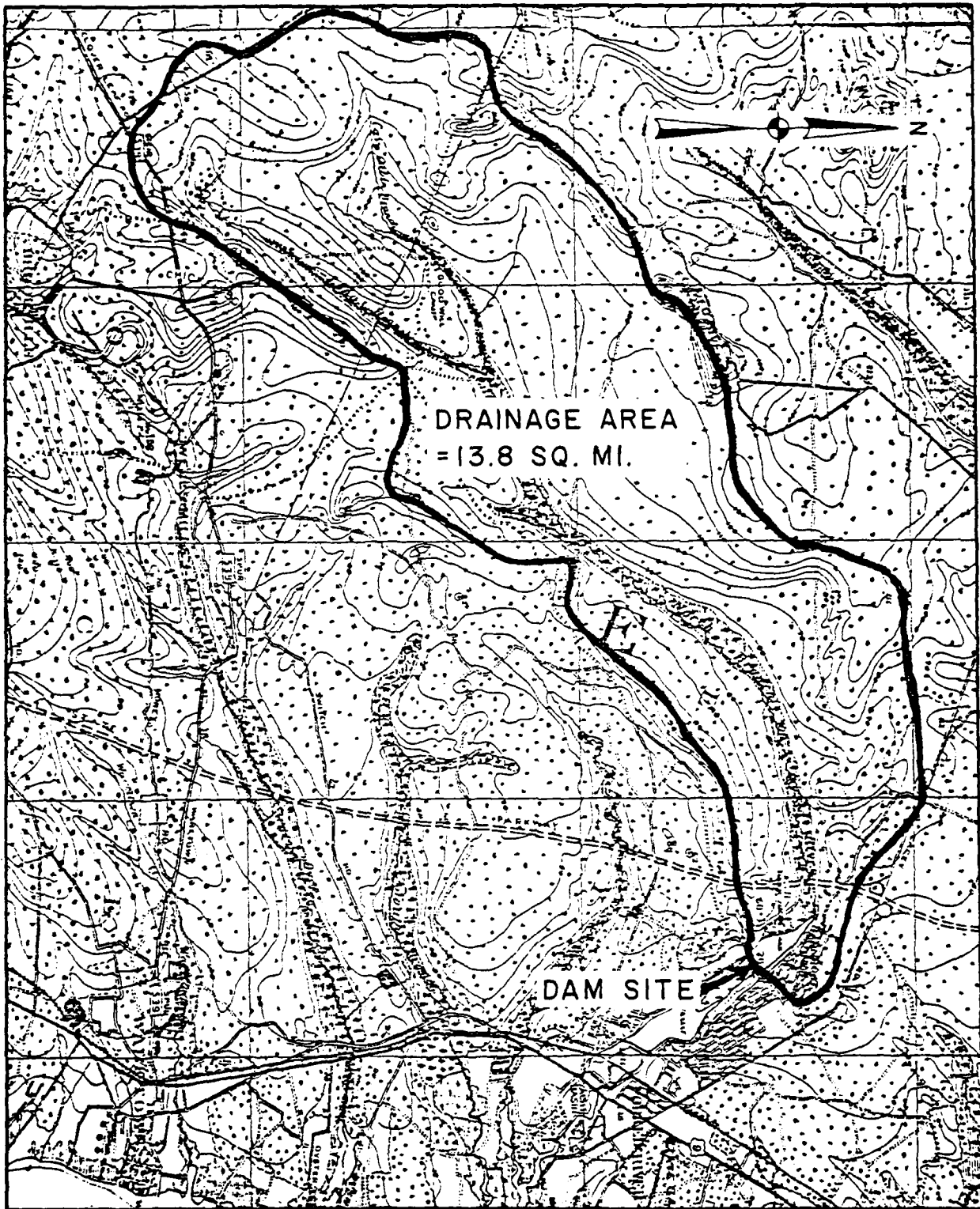
|             |      |
|-------------|------|
| a. Type     | None |
| b. Location | None |
| c. Records  | None |

MAXIMUM NON-DAMAGING DISCHARGE: 681 cfs at elevation 24.5 NGVD



APPENDIX D

HYDROLOGIC COMPUTATIONS



Scale: 1" = 1 Mile

DEER HEAD LAKE DAM  
DRAINAGE BASIN

PRC Harris, Inc.  
CONSULTING ENGINEERS

SUBJECT N. J. DAM INSPECTION  
Deer Head Lake Dam  
COMPUTED BY S.B. CHECKED BY \_\_\_\_\_

SHEET NO. 1 OF \_\_\_\_\_  
JOB NO. 10-1176-01  
DATE Feb, 1981

Area of the Lake at normal pool level

EL 22.5  $\rightarrow$  32 AC.

Height of the Dam = 9.4 Ft

Small Dam, High Hazard

S.D.F. =  $\frac{1}{2}$  PMF

Hydrologic Analysis:—

D.A. = 13.8 sq mi

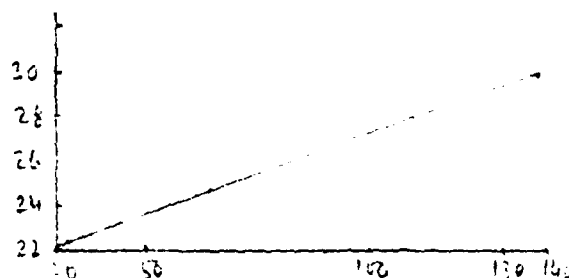
Inflow Hydrograph at reservoir was determined using HEC 1 DB program. Inflow routed through the Lake.

Elevation Area Capacity Relationship

Information obtained from R. LOUIS GALLAGHER ENGINEERING INC. and U.S.G.S

|                   |    |      |     |     |
|-------------------|----|------|-----|-----|
| EL                | 16 | 22.5 | 30  | 40  |
| Surface Area (Ac) | 0  | 32.0 | 138 | 344 |

HEC 1 DB program will develop storage capacity from surface area and elevation



Determination of PHP

Probable Maximum ppt. (inches) for an area of  
10 square miles and 6 hour duration  
= 26 "

D.A. = 13.8 sq. miles  
Zone = 6

The Corps of Engineers recommended that 19.525% reduction to be applied to the report value for a 10 sq miles drainage area in order to provide for the imperfect fit of the storm isohyetal patterns to the shape of the particular basin.

P.M.P. = 20.9" (this adjustment is made by the computer program)

Depth area duration relationship.

Percentage to be applied to the above 6 hr. PHP

|       |         |
|-------|---------|
| 6 hr  | = 100 % |
| 12 hr | = 108 % |
| 24 hr | = 117 % |
| 48 hr | = 127 % |

Initial infiltration = 1.0 inch/hr  
Constant infiltration = 0.1 inch/hr

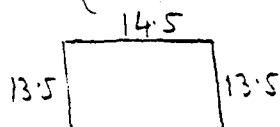
## Scheme of Dam and Spillway :-

Main Spillway :- Broad Crested One. weir  
(Left)  $C = 3.3$

$$L = 39'$$

$$El = 22.5 \text{ Ft}$$

Right Spillway :- Drop inlet  
(entrance from 3 sides)



$$\text{Effective length} = 41.5 \text{ Ft}$$

$$C = 3.3$$

$$\text{Elevation} = 22.75$$

Drop Spillway outlet through 72" CMP  
of 202 ft Long. El of Pipe invert = 13.3 Ft

Dam

$$\text{Effective length} = 660 \text{ Ft}$$

$$\text{Very Wide} \quad C = 2.5$$

Spot el  
of Dam  
at Drop inlet Spillway  
↓  
96.36

Spot el of  
Dam at Center  
near bath house  
↓  
96.82

Spot el  
of Dam at  
Weir  
↓  
97.76

$$\begin{aligned} \text{Average} &= 98.32 \quad (\text{This elevation is w.r.t} \\ \text{Subtract} &= -73.81 \quad \text{the elevation of Drop inlet} \\ &\quad \text{Spillway} = 96.56 \\ &\quad \hline &\quad 24.51 \end{aligned}$$

Say 24.5 (Top of Roadway)

Rating curve at the Drop inlet Spillway only

Using Chezy-Manning formula for flow through the pressure conduit

$$h_f = \frac{Q^2 n^2 L}{2.2 R^{4/3} A^2}$$

$$= \frac{(1.02)^2 \times 202}{2.2 (1.5)^{4/3} (28.3)^2} Q^2$$

$$= .00002671 Q^2$$

$$n = .02 \text{ (CMP)}$$

$$L = 202 \text{ Ft}$$

$$R = \frac{D}{4} = 1.5$$

$$A = \frac{\pi}{4} \times 6^2 = 28.3$$

$$Q_p = 193 \sqrt{h_p}$$

Tailwater is assumed = 15'

In the spillway

$$Q = C L h_s^{1.5}$$

$$= 3.3 \times 41.5 \times h_s^{1.5}$$

$$= 137 H_s^{1.5}$$

$h_s$  = head over spillway

| N. S. El | Head in Conduit $h_p$ | $Q_p$<br>$193 \sqrt{h_p}$ | Head in Spillway $h_s$ | $Q_s$<br>$137 H_s^{1.5}$ | Control  |
|----------|-----------------------|---------------------------|------------------------|--------------------------|----------|
| 22.75    | 7.75                  | 537                       | 0                      | -                        |          |
| 23.5     | 8.5                   | 562                       | .75                    | 89                       | Spillway |
| 24       | 9                     | 579                       | 1.25                   | 191                      | Spillway |
| 24.5     | 9.5                   | 595                       | 1.75                   | 317                      | "        |
| 26       | 11                    | 640                       | 3.25                   | 802                      | Pipe     |
| 28       | 13                    | 696                       | 5.25                   | 1648                     |          |
| 30       | 15                    | 747                       | 7.25                   | Not calculated           |          |
| 32       | 17                    | 795                       | 9.25                   | "                        |          |
| 34       | 19                    | 841                       | 11.25                  | "                        |          |

Rating Curve stage outflow relation: -

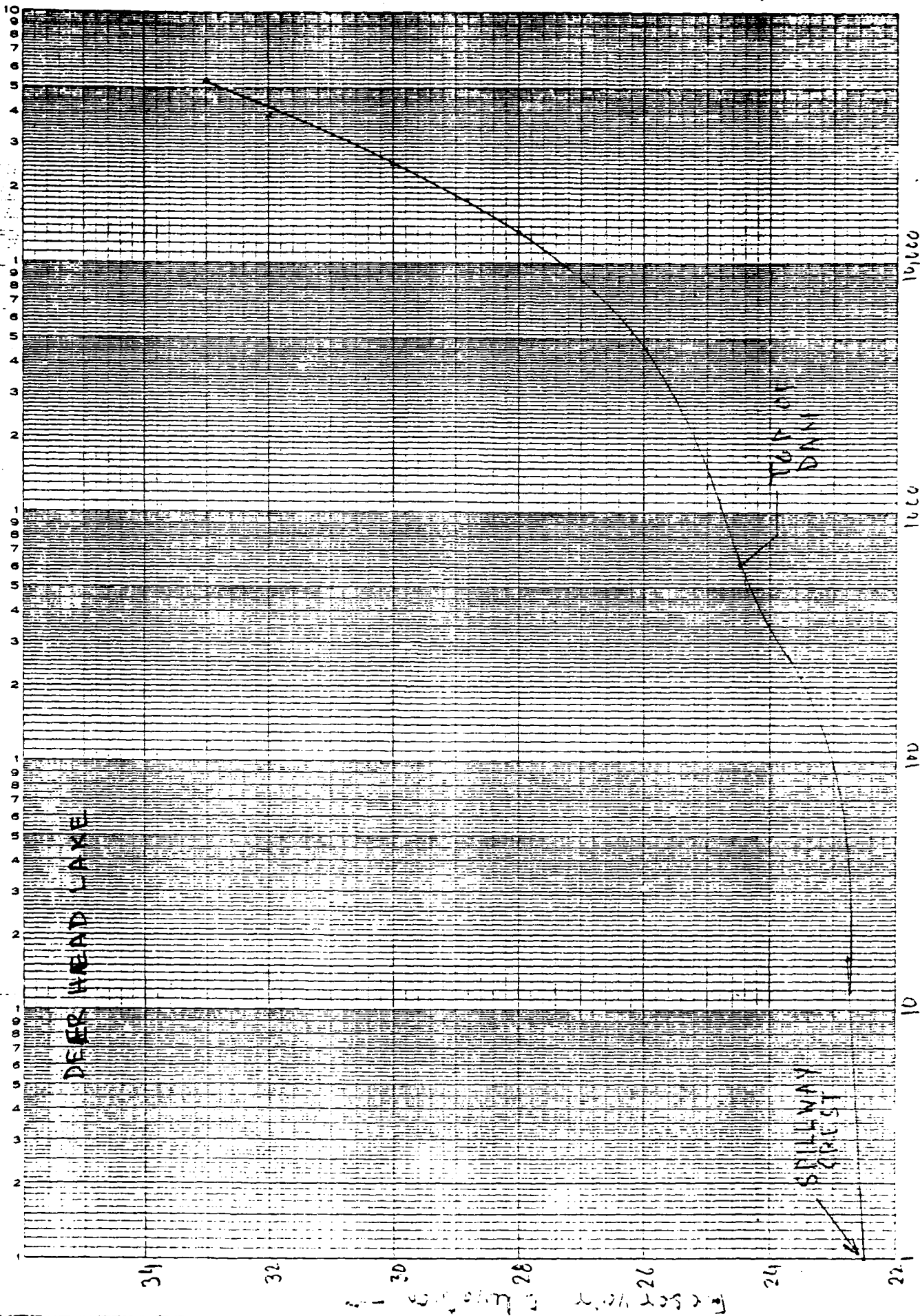
$$\text{Main Spillway } Q = C L H^{1.5} \\ = 3.3 \times 39 H^{1.5} = 128.7 H^{1.5}$$

$$\text{Dam } Q = C L H^{1.5} \\ = 2.5 \times 660 H^{1.5} = 1650 H^{1.5}$$

| W.S. El | head<br>in Main<br>Spillway | Q<br>128.7 H <sup>1.5</sup> | Q<br>Drop<br>in let<br>spillway | head<br>in<br>Dam | Q<br>1650 H <sup>1.5</sup> | Total   |
|---------|-----------------------------|-----------------------------|---------------------------------|-------------------|----------------------------|---------|
| 22.5    | -                           | 0                           | 0                               | 0                 | 0                          | 0       |
| 22.75   | .25                         | 16                          | -                               | -                 | -                          | 16      |
| 23.5    | 1.0                         | 129                         | 89                              | -                 | -                          | 218     |
| 24.5    | 2.0                         | 364                         | 317                             | -                 | -                          | 681     |
| 26      | 3.5                         | 843                         | 640                             | 1.5               | 3031                       | 4514    |
| 28      | 5.5                         | 1660                        | 696                             | 3.5               | 10,804                     | 13,160  |
| 30      | 7.5                         | 2643                        | 747                             | 5.5               | 21,283                     | 24,673  |
| 32      | 9.5                         | 3768                        | 795                             | 7.5               | 33,890                     | 38,453  |
| 34      | 11.5                        | 5019                        | 841                             | 9.5               | 48,314                     | 54,174  |
| 40      | 16.5                        | 8,626                       | 965                             | 14.5              | 91,104                     | 100,695 |

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PRC Harris, Inc.

CONSULTING ENGINEERS

SUBJECT N.J. Dam Inspection  
Deer head Lake Dam  
 COMPUTED BY S.B. CHECKED BY \_\_\_\_\_

SHEET NO. 7 OF \_\_\_\_\_  
 JOB NO. 10-1176-01  
 DATE Feb., 1981

## UNIT HYDROGRAPH

Unit Hydrograph coordinates  
 are adopted from information obtained  
 from C.O.E., Philadelphia.

1 Hr. U.H.G. coordinates.

|       |       |       |       |       |
|-------|-------|-------|-------|-------|
| 201 , | 491 , | 902 , | 993 , | 922 , |
| 802 , | 682 , | 561 , | 491 , | 431 , |
| 381 , | 331 , | 291 , | 251 , | 221 , |
| 201 , | 190 , | 180 , | 160 , | 150 , |
| 140 , | 120 , | 110 , | 100 , | 80 ,  |
| 70 ,  | 60 ,  | 50 ,  | 40 ,  | 35 ,  |
| 30 .  |       |       |       |       |

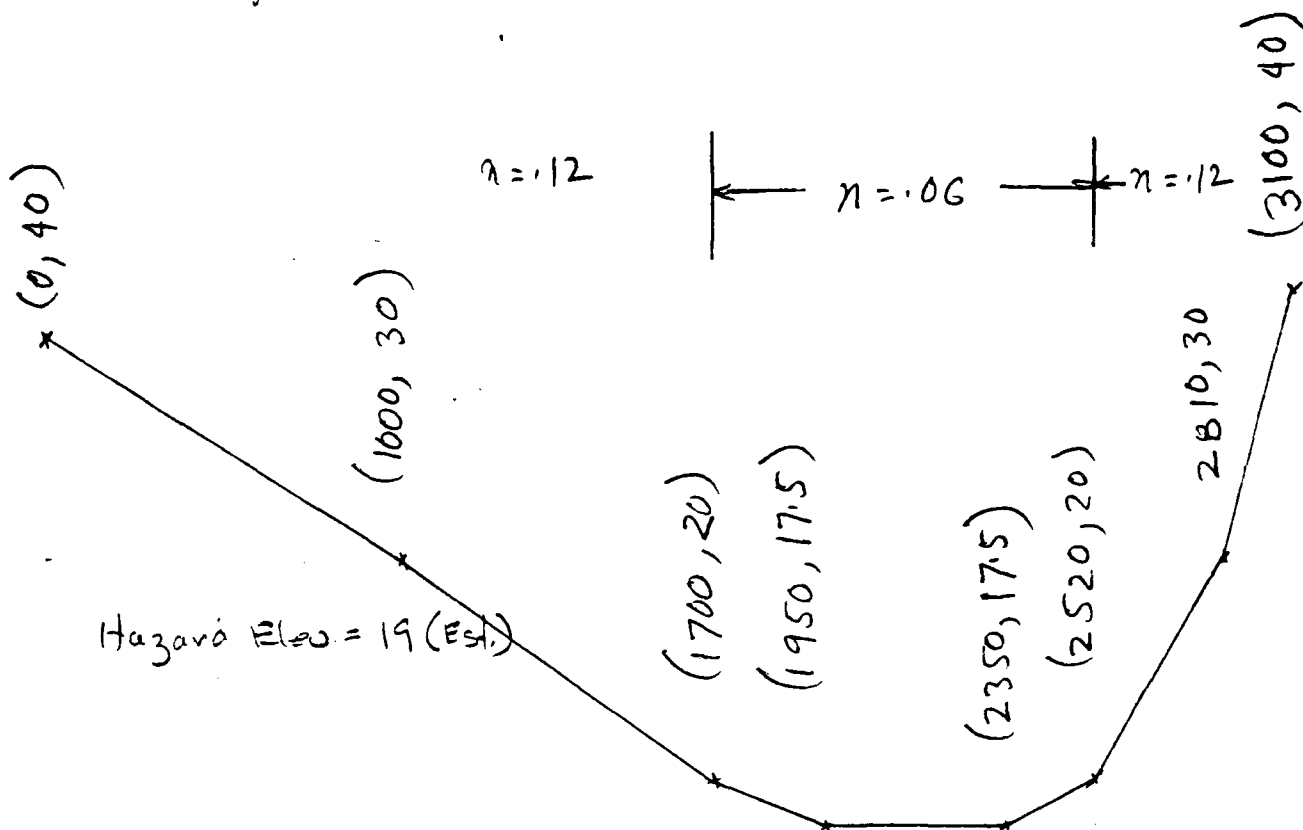
PRC Harris, Inc.  
CONSULTING ENGINEERS

SUBJECT N.J. Dam Inspection  
Deer head Lake Dam  
COMPUTED BY S.B. CHECKED BY \_\_\_\_\_

SHEET NO. 8 OF \_\_\_\_\_  
JOB NO. 10-1176-01  
DATE Feb, 1981

## CROSS SECTION AT D/S REACH

Reach is taken at ups end of Lake Barnegat.



REACH 1

$$L = 1600$$

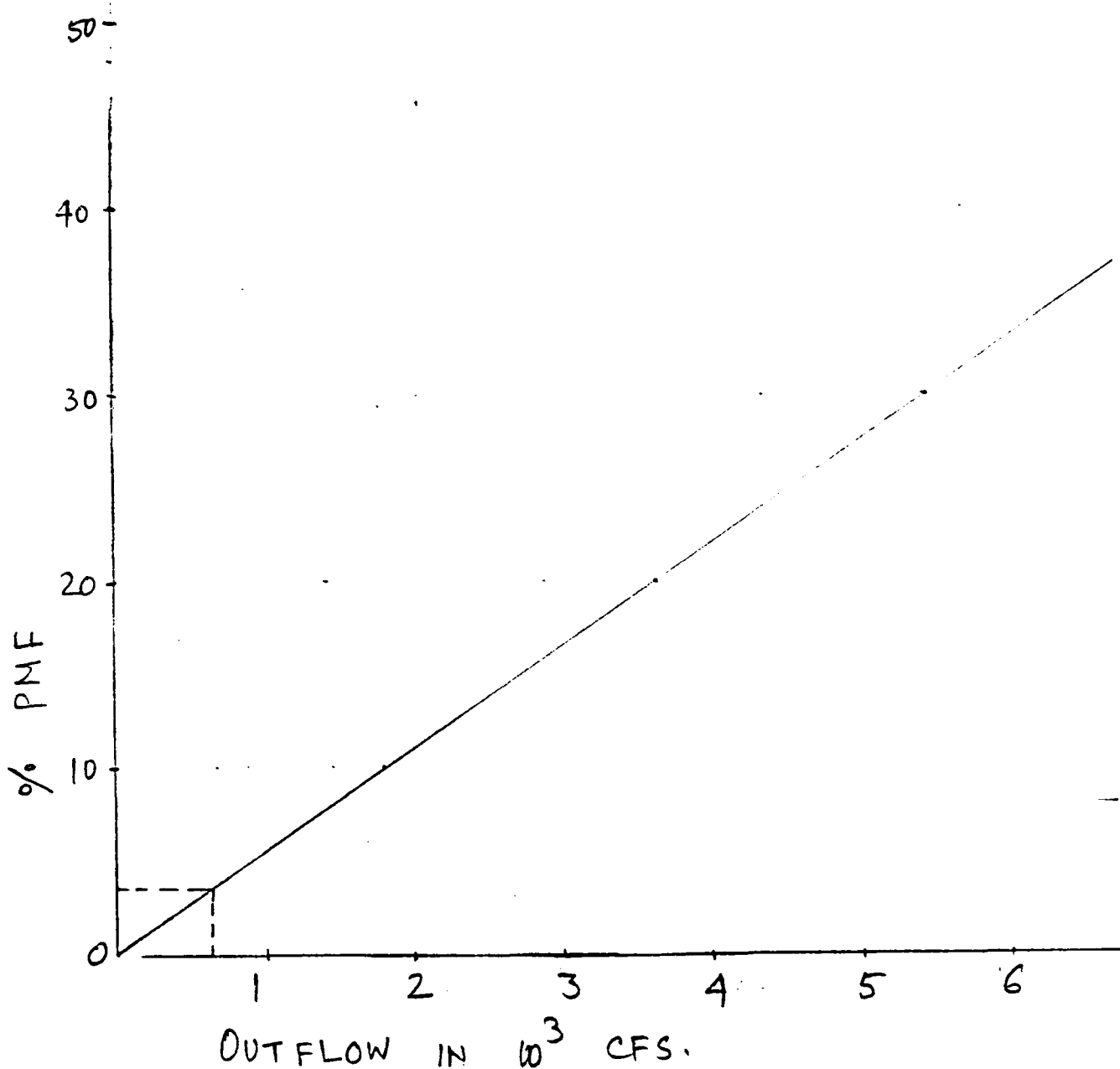
$$S = \frac{.5}{1600} = .0003$$

PRC Harris, Inc.  
CONSULTING ENGINEERS

SUBJECT N.J. Flood Ins. Study  
Deer head Lake Dam  
COMPUTED BY S.B. CHECKED BY \_\_\_\_\_

SHEET NO. 9 OF \_\_\_\_\_  
JOB NO. 10-1176-01  
DATE Feb, 1981

## Overtopping Potential

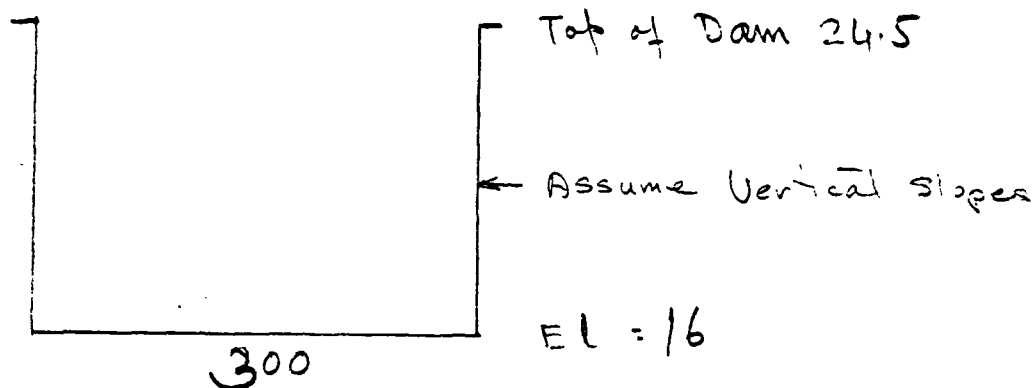


Overtopping of Dam occurs at El 24.50  
 $Q = 681$  cfs (3.7 % of PMF)

## Breach Analysis

Assume breach begins to develop when reservoir stage reaches above the dam.

Time of Failure = 41.0 hrs



Effect of breach was analysed 1,600 ft  
D/S of Dam.

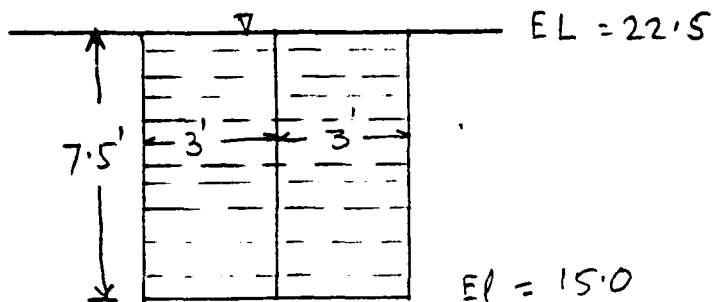
Max. stage without Dam break = 20.8

Max. stage with Dam break = 21.5

There will be 0.7' increase in W.S. El.  
due to Dam break at 0.10 PMF

Low level outlet

72" & 6' dia



When the planks are open Normal Elevation  
\* start = 22.7

$$\text{In flow } \frac{2 \text{ cfs}}{\text{mi}^2} \times 13.8 \text{ mi}^2 = 27.6 \text{ cfs.}$$

$$Q = CA \sqrt{2gh} \quad C = 0.62$$

$$Q = .62 A \sqrt{2gh}$$

Assume Tailwater = 16 Ft

$$A_2 = \left( \frac{h_2}{h_1} \right)^2 A_1 = \left( \frac{h_2}{6.5} \right)^2 \times 32 = .7574 h_2^2$$

$$(A_1 = 32 \quad h_1 = 6.5)$$

$$\text{Drawdown time} = \frac{\text{Vol in AF} \times 43560}{Q \times 3600} = \frac{\text{Vol} \times 12.1}{Q}$$

$$\text{Drawdown time with inflow} = \frac{27.6 \times t}{Q} \text{ Hrs.}$$

$$\text{Area of orifice} = \text{Variable with depth}$$

$$= 6' \times h$$

PRC Harris, Inc.  
CONSULTING ENGINEERS

SUBJECT N. J. Dam Inspection  
Deer head Lake Dam  
COMPUTED BY S. B. CHECKED BY \_\_\_\_\_

SHEET NO. 12 OF \_\_\_\_\_  
JOB NO. 10-1176-01  
DATE Feb., 1981

| Res<br>EI | Area<br>AC | Area<br>AV. | VOL  | AVG<br>RES FL.<br>FROM<br>TW | Area<br>of<br>orifice<br>6' x h | Q<br>62.4V <sup>3/2</sup><br>= 5A <sup>3/2</sup> | Drawdown<br>Vol x 12.1<br>Q | Cum.<br>time | Drawdown<br>with inflow<br>27.6 x t<br>Q | Cum<br>time |
|-----------|------------|-------------|------|------------------------------|---------------------------------|--|-----------------------------|--------------|--|-------------|
| ft        | AC         | AC          | AF   | ft                           | ft <sup>2</sup>                 | CFS  | HRS                         | HRS          | HRS                                      | HRS         |
| 22.5      | 32         | 27.5        | 27.5 | 6                            | 36                              | 440  | .75                         | .75          | .05                                      | .80         |
| 21.5      | 22.9       | 19.1        | 14.1 | 5                            | 30                              | 335  | .69                         | 1.44         | .06                                      | 1.55        |
| 20.5      | 15.3       | 12.3        | 12.3 | 4                            | 24                              | 240  | .62                         | 2.06         | .07                                      | 2.24        |
| 19.5      | 9.3        | 7.0         | 7.0  | 3                            | 18                              | 156  | .54                         | 2.6          | .10                                      | 2.88        |
| 18.5      | 4.7        | 3.2         | 3.2  | 2                            | 12                              | 85   | .46                         | 3.06         | .15                                      | 3.49        |
| 17.5      | 1.7        | 1.0         | 1.0  | 1                            | 6                               | 30   | .40                         | 3.46         | .37                                      | 4.26        |
| 16.5      | .2         | 0.1         | .05  | .5                           | 3                               | 11*  | .05                         | 3.51         | .13                                      | 4.44        |
| 16.0      | 0          |             |      |                              |                                 |  |                             |              |  |             |

Time of drawdown without inflow = 3.46 ≈ 3.5 hrs

Time of drawdown with const inflow = 4.26 ≈ 4.3 hrs.

\* Outflow becomes less than inflow. So drawdown is considered upto at elevation of 16.5







HYPERGEOMETRIC STATISTICS FOR CLASS 1. BY R. L. ...

|     | 6.  | 7.  | 8.  | 9.  | 10. | 11. | 12. | 13. | 14. | 15. | 16. | 17. | 18. | 19. | 20. | 21. | 22. | 23. | 24. | 25. | 26. | 27. | 28. | 29. | 30. | 31. | 32. | 33. | 34. | 35. | 36. | 37. | 38. | 39. | 40. | 41. | 42. | 43. | 44. | 45. | 46. | 47. | 48. | 49. | 50. | 51. | 52. | 53. | 54. | 55. | 56. | 57. | 58. | 59. | 60. | 61. | 62. | 63. | 64. | 65. | 66. | 67. | 68. | 69. | 70. | 71. | 72. | 73. | 74. | 75. | 76. | 77. | 78. | 79. | 80. | 81. | 82. | 83. | 84. | 85. | 86. | 87. | 88. | 89. | 90. | 91. | 92. | 93. | 94. | 95. | 96. | 97. | 98. | 99. | 100. |     |     |     |     |     |
|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|------|-----|-----|-----|-----|-----|
| 1   | 1   | 2   | 3   | 4   | 5   | 6   | 7   | 8   | 9   | 10  | 11  | 12  | 13  | 14  | 15  | 16  | 17  | 18  | 19  | 20  | 21  | 22  | 23  | 24  | 25  | 26  | 27  | 28  | 29  | 30  | 31  | 32  | 33  | 34  | 35  | 36  | 37  | 38  | 39  | 40  | 41  | 42  | 43  | 44  | 45  | 46  | 47  | 48  | 49  | 50  | 51  | 52  | 53  | 54  | 55  | 56  | 57  | 58  | 59  | 60  | 61  | 62  | 63  | 64  | 65  | 66  | 67  | 68  | 69  | 70  | 71  | 72  | 73  | 74  | 75  | 76  | 77  | 78  | 79  | 80  | 81  | 82  | 83  | 84  | 85  | 86  | 87  | 88  | 89  | 90  | 91  | 92  | 93  | 94  | 95   | 96  | 97  | 98  | 99  | 100 |
| 101 | 102 | 103 | 104 | 105 | 106 | 107 | 108 | 109 | 110 | 111 | 112 | 113 | 114 | 115 | 116 | 117 | 118 | 119 | 120 | 121 | 122 | 123 | 124 | 125 | 126 | 127 | 128 | 129 | 130 | 131 | 132 | 133 | 134 | 135 | 136 | 137 | 138 | 139 | 140 | 141 | 142 | 143 | 144 | 145 | 146 | 147 | 148 | 149 | 150 | 151 | 152 | 153 | 154 | 155 | 156 | 157 | 158 | 159 | 160 | 161 | 162 | 163 | 164 | 165 | 166 | 167 | 168 | 169 | 170 | 171 | 172 | 173 | 174 | 175 | 176 | 177 | 178 | 179 | 180 | 181 | 182 | 183 | 184 | 185 | 186 | 187 | 188 | 189 | 190 | 191 | 192 | 193 | 194 | 195 | 196  | 197 | 198 | 199 | 200 |     |

ROUTE 10 - ST. LOUIS, MISSOURI - MULTIPLE PLAN-RATIO ECONOMIC COMPUTATION  
 TIME IN CUBIC FEET PER SECOND (CUBIC METERS PER SECOND)  
 AREA 1.5000 MILES (SQUARE KILOMETER)

| SECTION  | STATION   | AREA  | PLAN | TIME   | PLAN   | TIME   | PLAN   | TIME  | PLAN | TIME |
|----------|-----------|-------|------|--------|--------|--------|--------|-------|------|------|
|          |           |       |      |        |        |        |        |       |      |      |
| ROUTE 10 | ST. LOUIS | 13.00 | 1    | 102    | 7200   | 5401   | 3641   | 1820  |      |      |
|          |           | 5.70  |      | 157.75 | 206.20 | 154.65 | 103.10 | 51.55 |      |      |
| ROUTE 10 | ST. LOUIS | 13.00 | 1    | 102    | 7200   | 5401   | 3641   | 1820  |      |      |
|          |           | 5.70  |      | 157.75 | 206.20 | 154.65 | 103.10 | 51.55 |      |      |
| ROUTE 10 | ST. LOUIS | 13.00 | 1    | 102    | 7200   | 5401   | 3641   | 1820  |      |      |
|          |           | 5.70  |      | 157.75 | 206.20 | 154.65 | 103.10 | 51.55 |      |      |

SUMMARY OF DAM SAFETY ANALYSIS

| SECTION  | STATION   | INITIAL VALUE | SPILLWAY CREST | TOP OF DAM | TIME OF FAILURE |
|----------|-----------|---------------|----------------|------------|-----------------|
|          |           |               |                |            |                 |
| ROUTE 10 | ST. LOUIS | 22.50         | 22.50          | 24.50      | 0.00            |
|          |           | 40            | 40             | 152        | 0.00            |
|          |           | 0             | 0              | 601        | 0.00            |
| ROUTE 10 | ST. LOUIS | 22.50         | 22.50          | 24.50      | 0.00            |
|          |           | 40            | 40             | 152        | 0.00            |
|          |           | 0             | 0              | 601        | 0.00            |

PLAN 1 - SECTION AHEAD

| SECTION  | STATION   | INITIAL VALUE | SPILLWAY CREST | TOP OF DAM | TIME OF FAILURE |
|----------|-----------|---------------|----------------|------------|-----------------|
|          |           |               |                |            |                 |
| ROUTE 10 | ST. LOUIS | 22.50         | 22.50          | 24.50      | 0.00            |
|          |           | 40            | 40             | 152        | 0.00            |
|          |           | 0             | 0              | 601        | 0.00            |
| ROUTE 10 | ST. LOUIS | 22.50         | 22.50          | 24.50      | 0.00            |
|          |           | 40            | 40             | 152        | 0.00            |
|          |           | 0             | 0              | 601        | 0.00            |



UNIT GRAPH TOTALS 9667. CFS OR 1.0 INCHES OVER THE AREA

UNIT GRAPH TOTALS 9667. CFS OR 1.0 INCHES OVER THE AREA

UNIT GRAPH TOTALS 9667. CFS OR 1.0 INCHES OVER THE AREA

# JOE SPECIFICATION

UNIT GRAPH TOTALS 9667. CFS OR 1.0 INCHES OVER THE AREA

UNIT GRAPH TOTALS 9667. CFS OR 1.0 INCHES OVER THE AREA

UNIT GRAPH TOTALS 9667. CFS OR 1.0 INCHES OVER THE AREA

## SUB-AREA RUNOFF COMPUTATION

UNIT GRAPH TOTALS 9667. CFS OR 1.0 INCHES OVER THE AREA

## HYDROGRAPH DATA

UNIT GRAPH TOTALS 9667. CFS OR 1.0 INCHES OVER THE AREA

## PRECIPITATION DATA

UNIT GRAPH TOTALS 9667. CFS OR 1.0 INCHES OVER THE AREA

UNIT GRAPH TOTALS 9667. CFS OR 1.0 INCHES OVER THE AREA

## LOCAL DATA

UNIT GRAPH TOTALS 9667. CFS OR 1.0 INCHES OVER THE AREA

UNIT GRAPH TOTALS 9667. CFS OR 1.0 INCHES OVER THE AREA

UNIT GRAPH TOTALS 9667. CFS OR 1.0 INCHES OVER THE AREA

## PRECIPITATION DATA

UNIT GRAPH TOTALS 9667. CFS OR 1.0 INCHES OVER THE AREA

## THREE-PEAK FLOW

UNIT GRAPH TOTALS 9667. CFS OR 1.0 INCHES OVER THE AREA



TABLE 10-1

(1) POINTS AT NORMAL TIME INTERVAL

(2) COMPUTED DISCHARGE

TIME  
(HRS)

| 00.       | 120. | 180. | 240. | 300. | 360. | 420. | 480. | 540. | 600. |
|-----------|------|------|------|------|------|------|------|------|------|
| 01.00 1.  |      |      |      |      |      |      |      |      |      |
| 01.05 2.  |      |      |      |      |      |      |      |      |      |
| 01.10 3.  |      |      |      |      |      |      |      |      |      |
| 01.15 4.  |      |      |      |      |      |      |      |      |      |
| 01.20 5.  |      |      |      |      |      |      |      |      |      |
| 01.25 6.  |      |      |      |      |      |      |      |      |      |
| 01.30 7.  |      |      |      |      |      |      |      |      |      |
| 01.35 8.  |      |      |      |      |      |      |      |      |      |
| 01.40 9.  |      |      |      |      |      |      |      |      |      |
| 01.45 10. |      |      |      |      |      |      |      |      |      |
| 01.50 11. |      |      |      |      |      |      |      |      |      |
| 01.55 12. |      |      |      |      |      |      |      |      |      |
| 02.00 13. |      |      |      |      |      |      |      |      |      |
| 02.05 14. |      |      |      |      |      |      |      |      |      |
| 02.10 15. |      |      |      |      |      |      |      |      |      |
| 02.15 16. |      |      |      |      |      |      |      |      |      |
| 02.20 17. |      |      |      |      |      |      |      |      |      |
| 02.25 18. |      |      |      |      |      |      |      |      |      |
| 02.30 19. |      |      |      |      |      |      |      |      |      |
| 02.35 20. |      |      |      |      |      |      |      |      |      |
| 02.40 21. |      |      |      |      |      |      |      |      |      |
| 02.45 22. |      |      |      |      |      |      |      |      |      |
| 02.50 23. |      |      |      |      |      |      |      |      |      |
| 02.55 24. |      |      |      |      |      |      |      |      |      |
| 03.00 25. |      |      |      |      |      |      |      |      |      |
| 03.05 26. |      |      |      |      |      |      |      |      |      |
| 03.10 27. |      |      |      |      |      |      |      |      |      |
| 03.15 28. |      |      |      |      |      |      |      |      |      |
| 03.20 29. |      |      |      |      |      |      |      |      |      |
| 03.25 30. |      |      |      |      |      |      |      |      |      |
| 03.30 31. |      |      |      |      |      |      |      |      |      |
| 03.35 32. |      |      |      |      |      |      |      |      |      |
| 03.40 33. |      |      |      |      |      |      |      |      |      |
| 03.45 34. |      |      |      |      |      |      |      |      |      |
| 03.50 35. |      |      |      |      |      |      |      |      |      |
| 03.55 36. |      |      |      |      |      |      |      |      |      |
| 04.00 37. |      |      |      |      |      |      |      |      |      |
| 04.05 38. |      |      |      |      |      |      |      |      |      |
| 04.10 39. |      |      |      |      |      |      |      |      |      |
| 04.15 40. |      |      |      |      |      |      |      |      |      |
| 04.20 41. |      |      |      |      |      |      |      |      |      |
| 04.25 42. |      |      |      |      |      |      |      |      |      |
| 04.30 43. |      |      |      |      |      |      |      |      |      |
| 04.35 44. |      |      |      |      |      |      |      |      |      |
| 04.40 45. |      |      |      |      |      |      |      |      |      |
| 04.45 46. |      |      |      |      |      |      |      |      |      |
| 04.50 47. |      |      |      |      |      |      |      |      |      |
| 04.55 48. |      |      |      |      |      |      |      |      |      |
| 05.00 49. |      |      |      |      |      |      |      |      |      |
| 05.05 50. |      |      |      |      |      |      |      |      |      |
| 05.10 51. |      |      |      |      |      |      |      |      |      |

PLAN RATIO AND COST PER UNIT OF OUTPUT SUMMARY FOR MULTIPLE PLAN-RATIO ECONOMIC COMPUTATIONS

| PLAN FLOW AT STATION (FEET OF HEAD) SUMMARY FOR MULTIPLE PLAN-RATIO ECONOMIC COMPUTATIONS |           |           |           |           |
|---|-----------|-----------|-----------|-----------|
| FLOW IN CUBIC FEET PER SECOND (CUBIC METERS PER SECOND)                                   |           |           |           |           |
| AREA IN SQUARE FEET (SQUARE KILOMETERS)   |           |           |           |           |
| RATIOS APPLIED TO FLOW  |           |           |           |           |
| NO. STATION   | PLAN AREA | PLAN AREA | PLAN AREA | PLAN AREA |
| 1   | 13.0      | 13.0      | 13.0      | 13.0      |
| 2   | 13.0      | 13.0      | 13.0      | 13.0      |
| 3   | 13.0      | 13.0      | 13.0      | 13.0      |
| 4   | 13.0      | 13.0      | 13.0      | 13.0      |
| 5   | 13.0      | 13.0      | 13.0      | 13.0      |
| 6   | 13.0      | 13.0      | 13.0      | 13.0      |
| 7   | 13.0      | 13.0      | 13.0      | 13.0      |
| 8   | 13.0      | 13.0      | 13.0      | 13.0      |
| 9   | 13.0      | 13.0      | 13.0      | 13.0      |
| 10  | 13.0      | 13.0      | 13.0      | 13.0      |
| 11  | 13.0      | 13.0      | 13.0      | 13.0      |
| 12  | 13.0      | 13.0      | 13.0      | 13.0      |
| 13  | 13.0      | 13.0      | 13.0      | 13.0      |
| 14  | 13.0      | 13.0      | 13.0      | 13.0      |
| 15  | 13.0      | 13.0      | 13.0      | 13.0      |
| 16  | 13.0      | 13.0      | 13.0      | 13.0      |
| 17  | 13.0      | 13.0      | 13.0      | 13.0      |
| 18  | 13.0      | 13.0      | 13.0      | 13.0      |
| 19  | 13.0      | 13.0      | 13.0      | 13.0      |
| 20  | 13.0      | 13.0      | 13.0      | 13.0      |
| 21  | 13.0      | 13.0      | 13.0      | 13.0      |
| 22  | 13.0      | 13.0      | 13.0      | 13.0      |
| 23  | 13.0      | 13.0      | 13.0      | 13.0      |
| 24  | 13.0      | 13.0      | 13.0      | 13.0      |
| 25  | 13.0      | 13.0      | 13.0      | 13.0      |
| 26  | 13.0      | 13.0      | 13.0      | 13.0      |
| 27  | 13.0      | 13.0      | 13.0      | 13.0      |
| 28  | 13.0      | 13.0      | 13.0      | 13.0      |
| 29  | 13.0      | 13.0      | 13.0      | 13.0      |
| 30  | 13.0      | 13.0      | 13.0      | 13.0      |
| 31  | 13.0      | 13.0      | 13.0      | 13.0      |
| 32  | 13.0      | 13.0      | 13.0      | 13.0      |
| 33  | 13.0      | 13.0      | 13.0      | 13.0      |
| 34  | 13.0      | 13.0      | 13.0      | 13.0      |
| 35  | 13.0      | 13.0      | 13.0      | 13.0      |
| 36  | 13.0      | 13.0      | 13.0      | 13.0      |
| 37  | 13.0      | 13.0      | 13.0      | 13.0      |
| 38  | 13.0      | 13.0      | 13.0      | 13.0      |
| 39  | 13.0      | 13.0      | 13.0      | 13.0      |
| 40  | 13.0      | 13.0      | 13.0      | 13.0      |
| 41  | 13.0      | 13.0      | 13.0      | 13.0      |
| 42  | 13.0      | 13.0      | 13.0      | 13.0      |
| 43  | 13.0      | 13.0      | 13.0      | 13.0      |
| 44  | 13.0      | 13.0      | 13.0      | 13.0      |
| 45  | 13.0      | 13.0      | 13.0      | 13.0      |
| 46  | 13.0      | 13.0      | 13.0      | 13.0      |
| 47  | 13.0      | 13.0      | 13.0      | 13.0      |
| 48  | 13.0      | 13.0      | 13.0      | 13.0      |
| 49  | 13.0      | 13.0      | 13.0      | 13.0      |
| 50  | 13.0      | 13.0      | 13.0      | 13.0      |
| 51  | 13.0      | 13.0      | 13.0      | 13.0      |
| 52  | 13.0      | 13.0      | 13.0      | 13.0      |
| 53  | 13.0      | 13.0      | 13.0      | 13.0      |
| 54  | 13.0      | 13.0      | 13.0      | 13.0      |
| 55  | 13.0      | 13.0      | 13.0      | 13.0      |
| 56  | 13.0      | 13.0      | 13.0      | 13.0      |
| 57  | 13.0      | 13.0      | 13.0      | 13.0      |
| 58  | 13.0      | 13.0      | 13.0      | 13.0      |
| 59  | 13.0      | 13.0      | 13.0      | 13.0      |
| 60  | 13.0      | 13.0      | 13.0      | 13.0      |
| 61  | 13.0      | 13.0      | 13.0      | 13.0      |
| 62  | 13.0      | 13.0      | 13.0      | 13.0      |
| 63  | 13.0      | 13.0      | 13.0      | 13.0      |
| 64  | 13.0      | 13.0      | 13.0      | 13.0      |
| 65  | 13.0      | 13.0      | 13.0      | 13.0      |
| 66  | 13.0      | 13.0      | 13.0      | 13.0      |
| 67  | 13.0      | 13.0      | 13.0      | 13.0      |
| 68  | 13.0      | 13.0      | 13.0      | 13.0      |
| 69  | 13.0      | 13.0      | 13.0      | 13.0      |
| 70  | 13.0      | 13.0      | 13.0      | 13.0      |
| 71  | 13.0      | 13.0      | 13.0      | 13.0      |
| 72  | 13.0      | 13.0      | 13.0      | 13.0      |
| 73  | 13.0      | 13.0      | 13.0      | 13.0      |
| 74  | 13.0      | 13.0      | 13.0      | 13.0      |
| 75  | 13.0      | 13.0      | 13.0      | 13.0      |
| 76  | 13.0      | 13.0      | 13.0      | 13.0      |
| 77  | 13.0      | 13.0      | 13.0      | 13.0      |
| 78  | 13.0      | 13.0      | 13.0      | 13.0      |
| 79  | 13.0      | 13.0      | 13.0      | 13.0      |
| 80  | 13.0      | 13.0      | 13.0      | 13.0      |
| 81  | 13.0      | 13.0      | 13.0      | 13.0      |
| 82  | 13.0      | 13.0      | 13.0      | 13.0      |
| 83  | 13.0      | 13.0      | 13.0      | 13.0      |
| 84  | 13.0      | 13.0      | 13.0      | 13.0      |
| 85  | 13.0      | 13.0      | 13.0      | 13.0      |
| 86  | 13.0      | 13.0      | 13.0      | 13.0      |
| 87  | 13.0      | 13.0      | 13.0      | 13.0      |
| 88  | 13.0      | 13.0      | 13.0      | 13.0      |
| 89  | 13.0      | 13.0      | 13.0      | 13.0      |
| 90  | 13.0      | 13.0      | 13.0      | 13.0      |
| 91  | 13.0      | 13.0      | 13.0      | 13.0      |
| 92  | 13.0      | 13.0      | 13.0      | 13.0      |
| 93  | 13.0      | 13.0      | 13.0      | 13.0      |
| 94  | 13.0      | 13.0      | 13.0      | 13.0      |
| 95  | 13.0      | 13.0      | 13.0      | 13.0      |
| 96  | 13.0      | 13.0      | 13.0      | 13.0      |
| 97  | 13.0      | 13.0      | 13.0      | 13.0      |
| 98  | 13.0      | 13.0      | 13.0      | 13.0      |
| 99  | 13.0      | 13.0      | 13.0      | 13.0      |
| 100   | 13.0      | 13.0      | 13.0      | 13.0      |

CONDUCT OF LAW SAFETY ANALYSIS

| STATION |           | ELEVATION   |                | INLET VALVE |         | SPILLWAY CATCH |             | TOP OF DAM     |            |
|---------|-----------|-------------|----------------|-------------|---------|----------------|-------------|----------------|------------|
| STATION | ELEVATION | INLET VALVE | SPILLWAY CATCH | TOP OF DAM  | STATION | ELEVATION      | INLET VALVE | SPILLWAY CATCH | TOP OF DAM |
| 1       | 122.0     | 122.0       | 122.0          | 122.0       | 2       | 122.0          | 122.0       | 122.0          | 122.0      |
| 3       | 122.0     | 122.0       | 122.0          | 122.0       | 4       | 122.0          | 122.0       | 122.0          | 122.0      |
| 5       | 122.0     | 122.0       | 122.0          | 122.0       | 6       | 122.0          | 122.0       | 122.0          | 122.0      |
| 7       | 122.0     | 122.0       | 122.0          | 122.0       | 8       | 122.0          | 122.0       | 122.0          | 122.0      |
| 9       | 122.0     | 122.0       | 122.0          | 122.0       | 10      | 122.0          | 122.0       | 122.0          | 122.0      |
| 11      | 122.0     | 122.0       | 122.0          | 122.0       | 12      | 122.0          | 122.0       | 122.0          | 122.0      |
| 13      | 122.0     | 122.0       | 122.0          | 122.0       | 14      | 122.0          | 122.0       | 122.0          | 122.0      |
| 15      | 122.0     | 122.0       | 122.0          | 122.0       | 16      | 122.0          | 122.0       | 122.0          | 122.0      |
| 17      | 122.0     | 122.0       | 122.0          | 122.0       | 18      | 122.0          | 122.0       | 122.0          | 122.0      |
| 19      | 122.0     | 122.0       | 122.0          | 122.0       | 20      | 122.0          | 122.0       | 122.0          | 122.0      |
| 21      | 122.0     | 122.0       | 122.0          | 122.0       | 22      | 122.0          | 122.0       | 122.0          | 122.0      |
| 23      | 122.0     | 122.0       | 122.0          | 122.0       | 24      | 122.0          | 122.0       | 122.0          | 122.0      |
| 25      | 122.0     | 122.0       | 122.0          | 122.0       | 26      | 122.0          | 122.0       | 122.0          | 122.0      |
| 27      | 122.0     | 122.0       | 122.0          | 122.0       | 28      | 122.0          | 122.0       | 122.0          | 122.0      |
| 29      | 122.0     | 122.0       | 122.0          | 122.0       | 30      | 122.0          | 122.0       | 122.0          | 122.0      |
| 31      | 122.0     | 122.0       | 122.0          | 122.0       | 32      | 122.0          | 122.0       | 122.0          | 122.0      |
| 33      | 122.0     | 122.0       | 122.0          | 122.0       | 34      | 122.0          | 122.0       | 122.0          | 122.0      |
| 35      | 122.0     | 122.0       | 122.0          | 122.0       | 36      | 122.0          | 122.0       | 122.0          | 122.0      |
| 37      | 122.0     | 122.0       | 122.0          | 122.0       | 38      | 122.0          | 122.0       | 122.0          | 122.0      |
| 39      | 122.0     | 122.0       | 122.0          | 122.0       | 40      | 122.0          | 122.0       | 122.0          | 122.0      |
| 41      | 122.0     | 122.0       | 122.0          | 122.0       | 42      | 122.0          | 122.0       | 122.0          | 122.0      |
| 43      | 122.0     | 122.0       | 122.0          | 122.0       | 44      | 122.0          | 122.0       | 122.0          | 122.0      |
| 45      | 122.0     | 122.0       | 122.0          | 122.0       | 46      | 122.0          | 122.0       | 122.0          | 122.0      |
| 47      | 122.0     | 122.0       | 122.0          | 122.0       | 48      | 122.0          | 122.0       | 122.0          | 122.0      |
| 49      | 122.0     | 122.0       | 122.0          | 122.0       | 50      | 122.0          | 122.0       | 122.0          | 122.0      |
| 51      | 122.0     | 122.0       | 122.0          | 122.0       | 52      | 122.0          | 122.0       | 122.0          | 122.0      |
| 53      | 122.0     | 122.0       | 122.0          | 122.0       | 54      | 122.0          | 122.0       | 122.0          | 122.0      |
| 55      | 122.0     | 122.0       | 122.0          | 122.0       | 56      | 122.0          | 122.0       | 122.0          | 122.0      |
| 57      | 122.0     | 122.0       | 122.0          | 122.0       | 58      | 122.0          | 122.0       | 122.0          | 122.0      |
| 59      | 122.0     | 122.0       | 122.0          | 122.0       | 60      | 122.0          | 122.0       | 122.0          | 122.0      |
| 61      | 122.0     | 122.0       | 122.0          | 122.0       | 62      | 122.0          | 122.0       | 122.0          | 122.0      |
| 63      | 122.0     | 122.0       | 122.0          | 122.0       | 64      | 122.0          | 122.0       | 122.0          | 122.0      |
| 65      | 122.0     | 122.0       | 122.0          | 122.0       | 66      | 122.0          | 122.0       | 122.0          | 122.0      |
| 67      | 122.0     | 122.0       | 122.0          | 122.0       | 68      | 122.0          | 122.0       | 122.0          | 122.0      |
| 69      | 122.0     | 122.0       | 122.0          | 122.0       | 70      | 122.0          | 122.0       | 122.0          | 122.0      |
| 71      | 122.0     | 122.0       | 1              |             |         |                |             |                |            |

